Measuring Access and Practice

Designing a Survey Methodology for the Hygiene, Sanitation and Water Sector

By

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— *Most of the things worth doing in the world have been declared impossible before they were done.*

— L. Brandeis

— *Our Age of anxiety is, in great part, the result of trying to do today's jobs with yesterday's tools*

— Marshall McLuhan

— The purpose of computing is insight, not numbers

— Hamming's moto

ABSTRACT

Access to safe water and sanitary means of excreta disposal are essential elements of human development and poverty alleviation. It is estimated that one in four people in the developing world lacks access to water while over half the population has no access to sanitation. From the Alma-Ata declaration in 1978 to the recent Millennium Development Goals, efforts to improve this situation have been hampered by the lack of meaningful indicators to measure hygiene, sanitation and water coverage and establish progress towards the goals and targets set out by the international community.

This thesis aims to determine if measuring prevalence of access to water, sanitation and the practice of hygienic behaviour in household surveys can be improved. With no indicators available in current international laws and targets, various aspects of access and practice were examined to design indicators for field-testing. By using existing data sets, the research established that there is a high geographic clustering of the measures of interest, which results in large design effects (*deff*) and rates of homogeneity (*roh*) in cluster surveys. Based on the calculated *roh* optimum numbers of cluster and sample size were calculated for the field trials. This requires introducing survey costs in the sample size calculations. The high clustering of water and sanitation indicator require large sample sizes, resulting in large amounts of data which organisations in the four field trials in Kosovo, South Africa, Kenya and Laos found difficult to handle. Practical problems in the implementation of the survey method resulted in non-sampling errors and could cause reluctance in adoption the methodology. The research improved water and sanitation indicators but found that for individual behaviour such as hygiene the household is not a suitable sampling unit. It also showed that observation among interviewers have to be better standardised to reduce the inter-surveyor variation. Representative sampling is the current bottleneck in the development of such a survey method. Current method requires a good understanding of sampling theory as well as reliable sample frames, which are rarely available to implementing organisations. Alternative sampling methods are suggested, and recommendations are made for the further development of the survey method designed in this research, which to date may be too complex for widespread use.

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GLOSSARY

AAPOR	American Association for Public Opinion Research
AFNOR	Association Française de Normalisation (French national organisation for standardisation)
ASP	Active Server Pages, Software protocol to make information available in web browsers such as used visualising information from the WWW
BSU	Basic sampling unit (households in the case of the WaSH survey)
CAPI	Computer-assisted personal interview
CDC	Centre for Disease Control in Atlanta (USA)
CI	Confidence Interval (in statistics) of an estimation
Cluster	Selected primary sample unit (PSU)
CTPC	Lao ministry of Communication, Transport, Post, and Construction
DCTPC	Department of CTPC
DD	Diarrhoeal disease(s)
DFID	UK Department for International Development
DHS	Demographic Health Survey for USAID
DOW I	Drawers of Water one see bibliography (White 1972)
DOW II	Drawers of Water two see bibliography (Thompson 2002)
EAR	European Agency for Reconstruction
EEC	European Economical Community
EU	European Economical Union
Earth Summit	UN Summit for Sustainable Development
EHG	Environmental Health Group at LSHTM
EPI	Enlarged Programme of Immunisation by WHO/UNICEF
EHP	Environmental Health Programme supported by USAID
EPSEM	Equal probability of selection method (see also self-*weighted*)
Flying toilets	*Wrap* excreta and *throw* away as means of excreta 'disposal'
GHS	Global Health Survey by WHO
IAP	Iguaçu Action Plan (WSSCC 2000)
IPH	Institute of Public Health (Kosovo's IPH in this document)
IRC	International Water and Sanitation Centre, based in The Hague
LSHTM	London School of Hygiene and Tropical Medicine

LSMS	Living Standards Measuring Study by the World Bank
mb	mega bytes measure of computer memory and data storage
MEP	Minimum Evaluation Procedure for 'WatSan' projects by WHO
MICS	Multiple Indicator Cluster Survey
MoH	Ministry of Health
Nam Saat	National Centre for Environmental Health and Water Supply in Laos
NETWAS	Network for Water and Sanitation
NGO	Non Governmental Organisation
NSC	National Statistical Centre in Laos
OCR-Macro	Company responsible for the DHS surveys supported by USAID
PAPI	Paper and Pencil personal Interview
PC	Personal Computer
PDR	(Lao's) People's Democratic Republic
Population	Statistically it all the BSU's that have a chance of being selected; It is also the level at which statistical inference is made.
PPES	Probability Proportionate to Estimated Size
PPS	Probability Proportionate to Size
PSU	Primary Sample Unit
SARAR	Self-esteem, Associative strength, Resourcefulness, Action planning and Responsibility
Self weighted	Equal (non-zero) probability, no need to apply sample weights
SQL	Scripted Query Language, a database software protocol
Take	Number of BSU's selected in a cluster to contribute to the sample
UDAA	Laos Urban Development Administration Authority
UN	United Nations
UNESCO	UN Educational, Scientific and Cultural Organisation
UNGEMI Water:	One of the South Africa'sn water utilities
UNHCR	United Nation High Commission for Refugees
UNMIK	United Nations Mission in Kosovo
URI	Lao Urban Research Institute
USAID	Unite States Agency for International Aid
VB	Visual Basic™, software language developed by Microsoft™
VIP latrine	Ventilated Improved Pit latrine
WASH	Contraction of Water Sanitation and Hygiene as a discipline or sector

WaSH	Sector specific survey methodology developed in this thesis
WaSA	Water and Sanitation Authority in Laos
WatSan	Contraction of Water and Sanitation often includes hygiene behaviour
WEDC	Water Engineering and Developing Centre at the University of Loughborough in the UK.
WELL	Water and Environmental health at Loughborough and London resource centre funded by DFID
WSP	Water and Sanitation Programme of the World Bank
WSP-EAP	WSP for the East Asian and Pacific Region
WSSCC	Water Supply and Sanitation Collaborative Council
WHO	United Nation World Health Organisation
WWW	World Wide Web, part of the internet, which uses Web-protocols.

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PAGE NUMBERING AS ORIGINAL

CHAPTER 1 INTRODUCTION

Access to safe water and sanitary means of excreta disposal are a universal need and a basic human right (UN 1948, 1966, 1989, 2002a). They are essential elements of human development and poverty alleviation and constitute an indispensable component of preventive healthcare (WHO/UNICEF 1978).

Despite this, it is estimated that almost one in four people in the developing world lacks access to water while over half the population has no access to sanitation (WHO/UNICEF 2004).

This introduction will describe:

- a short history of water and sanitation goals
- the background of the research,
- a brief definition of the problem
- the study's hypothesis
- the aims of the research project
- a brief overview of the project's course
- the structure of the dissertation

1.1 A short history of water and sanitation goals

Widespread concern to ensure safe water and sanitary disposal of excreta and waste water, especially in developing countries led in 1978 to the Alma-Ata declaration stating that "*Adequate supply of safe water and basic sanitation*" are considered "*...methods of preventing and controlling ... prevailing health problems*" (WHO/UNICEF 1978). This declaration on Primary Health Care was based on the World Health Assembly's resolution of 1977 which set as a target, "*Health for All by the Year 2000*" (Banerji 2003).

The declaration and the underlying concern led to the UN resolution 35/18 on 10 November 1980, which proclaimed the period 1981-1990 as the International Drinking Water Supply and Sanitation Decade. The UN declared that the next ten years would bring "*Safe water and sanitation for all by 1990*". Every day in the 1980s, approximately 200,000 people gained a safe supply of drinking water and

80,000 a better means of sanitation (Appleton 1990). This was twice the rate of the 1970s, according to the World Health Organization (WHO) which was responsible for compiling the Decade's statistics. However, the International Drinking Water Supply and Sanitation Decade ended without reaching its declared goal (Diamant 1992). The extra 715 million people with new taps and pumps towards the end of the decade hardly outpaced the population growth in the Third World of 614 million people over the same period (Appleton 1990). Nonetheless valuable lessons were learned, not least that setting unrealistic targets is counterproductive, and that simply counting new installations was not a constructive way to evaluate the Decade (Appleton 1990). According to the International Institute for Sustainable Development (IISD), one of the ten lessons learned from the decade was the importance of monitoring, since "*you can't manage what you can't measure*" (Creech 2002). IISD also states that one of the obstacles on the road to sustainability in the sector has been a lack of meaningful indicators to "*...tell us our current situation, which way we are moving, and how rapidly we are progressing*" (Creech 2002).

In March 2000, the Water Supply and Sanitation Collaborate Council (WSSCC) published "Vision 21" (WSSCC 2002) to set the agenda for the water, sanitation and environmental hygiene sector in the first quarter of the 21st century. The WSSCC was formed in the wake of the 1980s Water Decade as a follow-up to the 1988 External Support Agency (ESA) Collaborative Council. Its main task was, and still is to enhance collaboration in the water supply and sanitation sector, specifically in order to attain universal coverage of water and sanitation services for poor people around the world. "Vision 21" sets targets in water, sanitation, hygiene behaviour with an additional focus on sanitation, and hygiene education in schools.

The 1992 the World Summit on Sustainable Development in Rio and other international conferences and summits since have produced numerous targets. Combined with Vision 21 these were compiled into the **International Development Goals**, unanimously adopted by United Nations member states in September 2000 as the Millennium Declaration (UN 2000). With regard to water, item 19 states (amongst other commitments): "*we resolve further..., by the year 2015,... to halve the proportion of people who are unable to reach or to afford safe drinking water*" (UN 2000). There was no mention of sanitation or hygiene behaviour in the declaration. A year later as a follow-up on the Millennium Declaration, the United Nations agreed on the Millennium Development Goals or MDG (UN 2001a, 2001b) as part of the

'Road Map' for implementing the Millennium Declaration. The documents list eight goals which each have targets. Each target has indicators which will be measured to monitor process towards its goal. Water in the MDG is found as shown in Figure 1.1.

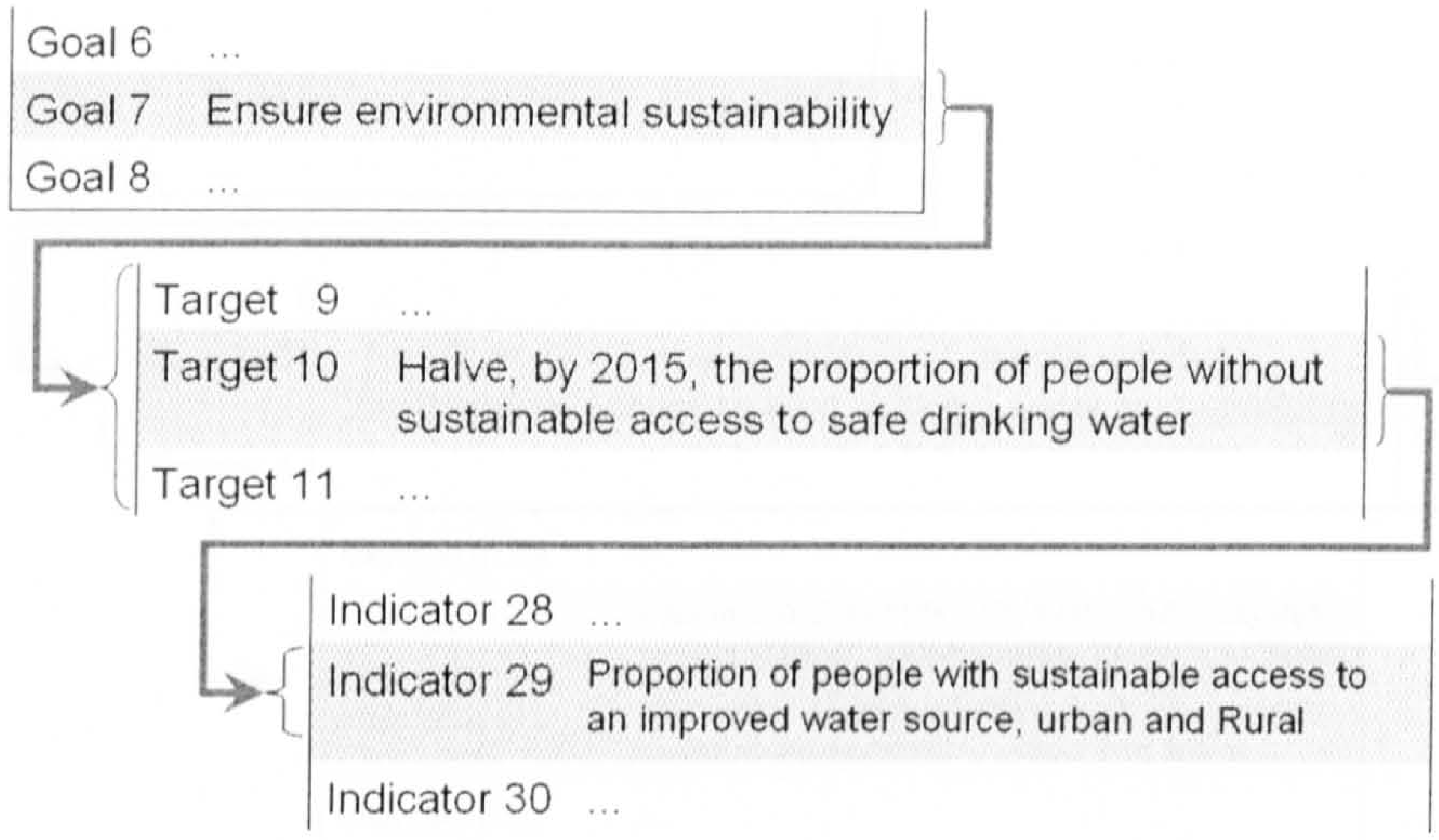

Figure 1.1: MDG target and indicator regarding water as published on 6 September 2001

The roadmap to the MDG regularly refers to sanitation and even recognises it as "*a priority area*". Despite that sanitation did not get a specific MDG target. It was only mentioned as an indicator of a goal in Target 11 which states: "*By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers*". At the 2002 World Summit on Sustainable Development in Johannesburg (UN 2002d) a clear commitment was made towards sanitation. The report of the summit even outlined specific actions (UN 2002d):

a) Develop and implement efficient household sanitation systems;
b) Improve sanitation in public institutions, especially schools;
c) Promote safe hygiene practices;
d) Promote education and outreach focused on children, as agents of behavioural change;
e) Promote affordable and socially and culturally acceptable technologies and practices;
f) Develop innovative financing and partnership mechanisms;
g) Integrate sanitation into water resources management strategies.

The Johannesburg summit led to a more comprehensive reformulation of the MDG (UN 2001a, 2002c) as follows:

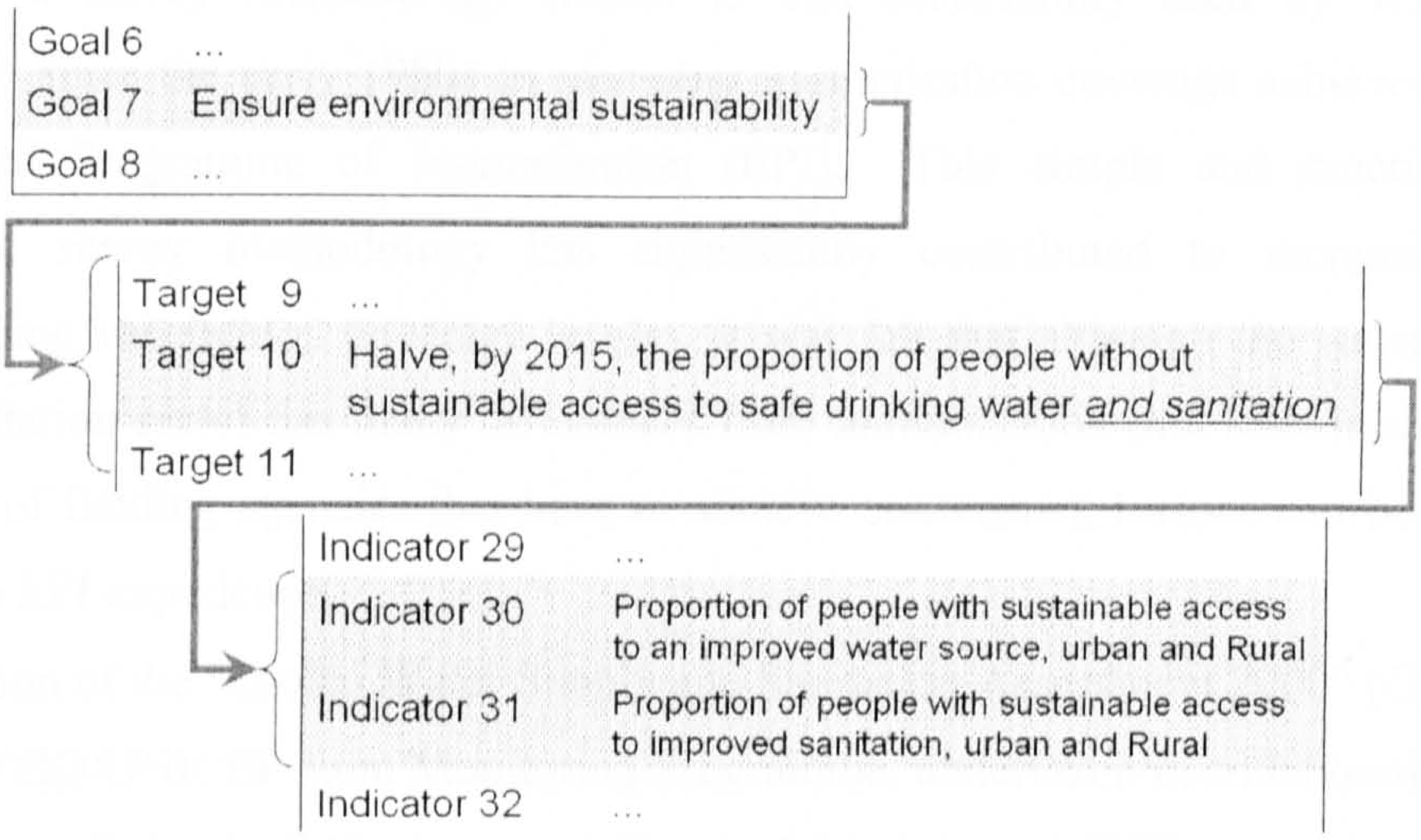

Figure 1.2: Water and sanitation MDG as after Johannesburg World Summit

The responsibility for monitoring MDG Target 10 is shared by UNICEF and WHO (UN 2002c) who formed in 1990 the Joint Monitoring Programme (JMP) to execute such tasks. The formal reporting on the MDG and on target achievement is contained in the Secretary-General's annual progress report to the United Nations General Assembly on the Millennium Declaration (UN 2002b). In the Road Map towards the implementation of the United Nation Millennium Declaration it was stated that "*for the purpose of measuring progress the normal baseline year for the MDG will be 1990*" (UN 2001b). That baseline for Target 10 was provided by the JMP in its Global Water Supply and Sanitation Report 2000 (WHO/UNICEF 2000).

On 9 February 2004, following the 2003 "Year of Freshwater", the UN General Assembly declared the period from 2005 to 2015 as the International Decade for Action: "*Water for Life*", beginning on World Water Day, March 22, 2005. One of the aims of this declaration was to renew attention in the MDG and achieving that goal as the Decade will end at the same time as the target year for goal seven of the MDG. The JMP provided the baseline for the "Water for Life Decade" (UN 2005) by publishing their Mid-Term Assessment on progress towards the MDG (WHO/UNICEF 2004)

1.2 The background of the study

The initial inspiration for the study was Sir Richard Jolly, former Deputy Executive Director of Programmes in UNICEF and later Chair of the WSSCC. His idea was to develop a survey methodology similar to that successfully used by WHO and UNICEF since the early 1980s in assessing immunisation coverage achieved by the Expanded Programme of Immunisation (EPI). This simple and practical EPI coverage survey methodology has significantly contributed to increasing and maintaining vaccination coverage levels. It was felt that although the water supply and sanitation sector has many differences from immunisation (not least in the larger number of funding agencies that have to achieve consensus), lessons can be learned from the EPI experience.

Publication of the "Global Water Supply and Sanitation Assessment 2000" (GWSSA) by the WHO/UNICEF Joint Monitoring Programme, undertaken in collaboration with the London School of Hygiene and Tropical Medicine (LSHTM), marked a first change in assessing coverage figures. The major difference with the 2000 Global Assessment (GA2000) in comparison to previous JMP reports was the shift from providers' estimates to survey-based estimates for the basis of the statistics. This population-based approach increased in some ways the reliability of the data, but also underlined the importance and weaknesses of sector monitoring revealed by persistent methodological challenges.

The 5th Global WSSCC Forum in Iguaçu expressed the need for a sector specific survey and data analysis methodologies. This aspect was considered so important that the "Iguaçu Action Programme (IAP)" stipulated that WSSCC adopt monitoring as a central component of its activities (WSSCC 2000a). The IAP includes key action points to facilitate better monitoring in the sector through:

1. Development of improved indicators of coverage and hygiene awareness and practices
2. Development of survey methodologies specific to the needs of the sector
    a. Define, test and validate a core set of indicators for measuring VISION 21
    b. Build consensus on methodologies for data collection
    c. Encourage the analysis, use and accessibility of generated information

WSSCC commissioned LSHTM to draft a sector-specific water, sanitation and (if possible) hygiene behaviour survey methodology.

1.3 Defining the general problem

Access to water and sanitation services is a global problem, but there are no clear and universally accepted definitions for access to water and sanitation, or of what constitutes 'good' hygiene behaviour. Different surveys collect and analyse data in different ways which makes data difficult to aggregate and compare. Surveys such as those shown in Table 1.1 have a high level of standardisation, cover large geographical areas and are usually done at regular intervals.

Survey	Promoting institution	Main focus
• National Census	National government / UNPD / UNFPA	Demographic
• Demographic Health Survey (DHS)	United States Agency for International Development (USAID)	Demographic
• Multiple Indicator Cluster Survey (MICS)	United Nations Children Fund (UNICEF)	Mother and Child Health
• Global Health Survey (GHS)	World Health Organisation (WHO)	Health
• Living Standards Measurement Study (LSMS)	World Bank (WB)	Household economics

Table 1.1: Main national surveys with promoting organisation and main survey focus

They are all based on representative sampling although the decennial census uses a considerably larger sample size compared to any of the other surveys. Their large standardisation and national coverage makes them more suitable for comparable studies such as the 2000 Global Assessment. However these are not compiled by or for the water and sanitation sector, and therefore use different and often inappropriate definitions of coverage (EHP 2004; WSSCC 2000b). Because of their different focus, these surveys rarely collect information on hygiene behaviour. Moreover, the results of these surveys can seldom be broken down for analysis at a local level. National census data can be broken down by region or district, but the long time

interval between censuses and the delay with which the data usually become available limits their applicability for monitoring progress in the water sector.
These major problems with existing survey methods are summarised in Box 1.1.

Problems with existing water, sanitation and hygiene behaviour surveys data:

- Focus on other sectors so 'WatSan' questions are often omitted from survey;
- They rarely collect information on hygiene behaviour;
- They use different standards and definitions, often inappropriate ones;
- Data are mainly at national level with little possibility of disaggregating;
- Time interval between surveys makes them unsuitable for project monitoring.

Box 1.1: Existing surveys and water, sanitation and hygiene behaviour data.

1.4 Hypothesis

The rationale underlying the work is that enabling people to measure access to water and sanitation as well as hygiene behaviour in a convenient, affordable and internationally accepted way will improve progress towards achieving the MDG and Vision 21 Targets. It is assumed that having this easy way of measuring the current situation allows people to better target their resources, reveals where advocacy is required and enables demonstrating progress which is measured through an accepted methodology. However testing this would be far too ambitious for a PhD thesis.
This thesis will test whether:

People currently active in the water, sanitation and hygiene behaviour sector, with no particular background in data collection, can be equipped with a method to measure in a representative way the proportion of people that have access to 'improved' water sources, 'improved' sanitation, and adhere to 'improved' hygiene behaviour.

Box 1.2: Hypothesis of this thesis

This hypothesis is tested by developing such a sector specific survey methodology and observe its implementation by various organisations active in the water, sanitation and hygiene behaviour sector.

1.5 Aims of the research

In order to attain the MDG Target 10, or even merely to improve global access to water and sanitation, it is important to measure and quantify such access (Creech 2002; WHO/UNICEF 2000) To achieve this, the WSSCC expressed in its Iguaçu Action Programme (IAP) the need for better universal methodologies for measuring access to water and sanitation (WSSCC 2002).

The aim of the research is to study a simple sector-specific cross-sectional household survey methodology that allows data collection by statistically-untrained people at the project implementation level as well as on a national level, in such a way that its results are credible to the wider community, particularly project implementers and policy makers.

The specific research question is:

Can people *untrained in survey methodologies* measure in a *representative* way, and at *reasonable* cost, *summative* information on a population's:

- adherence to 'improved' hygiene practices[1];
- access to 'improved' sanitation;
- access to 'improved' water sources;

in a *specified* region such as a country, province, district, or city.

Box 1.3: Research question

Summative in this thesis means describing the population as a proportion of people having access to water and sanitation, or adhering to particular hygiene practices.

[1] Through internationally recognition of the MDG they have taken precedent over V21 and as such this thesis will often refer them. While hygiene practices are part of V21 they are not part of the MDG.

This is in contrast with *normative* information which is more diagnostic describing why the situation is as 'described' in a summative way.

1.6 Brief overview of the course of the project

In response to a request from Sir Richard Jolly, the London School of Hygiene and Tropical Medicine introduced through its WELL[2] collaboration a proposal to UK Department for International Development (DFID). This proposal aimed to develop a sector-specific sample survey methodology to measure water and sanitation coverage at national, regional or district level. DFID, concerned that the ownership of the product should be sector-wide, agreed that the Collaborative Council (WSSCC) should commission the work. Delays in funding prompted the Environmental Health Programme (EHP) to partially fund the initial development of the *WaSH* survey methodology. This resulted in three documents by the author which formed the basis for the WSSCC Monitoring Task Group meeting in Geneva on 18-19 June 2002. The feedback received from this meeting formed the basis of a new document by the author in September 2002 as starting point for the planned trials. Of the minimum six trials considered necessary during the meeting, none took place. Instead other possibilities were explored. The first was in July 2002 when an MSc student at LSHTM was willing to use the revised document as the basis for evaluation of a water and sanitation project in Kosovo. The second was towards the end of 2002 when Umgeni Water in South Africa was keen to use the existing protocol to evaluate the water and sanitation situation in Kwazulu Natal. Opportunities for the writer to become directly involved in surveys became possible in January 2003 when funding was awarded by WSSCC for a survey in Kenya. In August the same year, the World Bank agreed to fund a survey in Laos which became the last of four pilot surveys. These surveys are discussed in more detail in Chapter 7 of this thesis.

[2] WELL is a resource centre funded by the UK Department of Foreign International Development

1.7 Structure of this thesis

Chapter 1: Introduction
Research goals and question, including a brief history of the project.

Chapter 2: Defining the problem
Divides the project into constituent problems which are briefly discussed.

Chapter 3: Existing definitions and indicators
Reviews existing indicators in international law, targets and definition of needs as a basis for developing various indicators

Chapter 4: *WaSH* definitions and indicators
Lacking existing indicators this chapter aims to define measurable indicators for the survey methodology.

Chapter 5: Household survey sampling
Discuss representative sampling and how to apply it in a practical sampling plan.

Chapter 6: Practical implementation
Problems and solutions relating to data collection, -coding, -capturing, -analysis and presentation of results as well as making collected information available for further use.

Chapter 7: Field testing of the methodology
Narrative of the four trials testing various aspects of the survey methodology in which the author was involved.

Chapter 8: Analysis and validation of the methodology
Analysis of the data collected in the two surveys in which the author was fully involved.

Chapter 9: Discussion of methodology
Discussion of all aspects of the survey methodology.

Chapter 10: Conclusions and recommendations
Conclusion that can be drawn from the presented research and recommendations for the future.

CHAPTER 2 DEFINING THE PROBLEM

The overall aim of the research project was set out in the Introduction chapter. This chapter describes the research problem in more detail by dividing the study up into constituent parts and touching on the various facets and concepts regarding each of the defined pieces.

To design a simple but accurate cross-sectional household survey method to measure Vision 21 targets and Millennium Development Goals, the work has been divided as shown in Figure 2.1 and as discussed below.

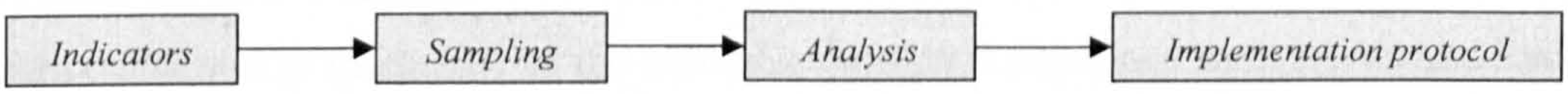

Figure 2.1: Major parts of the project

The **first part** of the research is to identify reliable and timely data that can be easily collected in a cross-sectional household survey at a low cost and with local means, in order to compile acceptable indicators of access and practice. This process will have to be done separately for each of the three indicators:

- access to water;
- access to sanitation and;
- practice of hygiene behaviour.

This chapter will look at the general issues that relate to all three indicators while the definition and discussion on each individual indicator is outlined in Chapters 3 and 4.

The **second part** of this research is to identify a practical sampling method that allows representative sampling by people who have little or no formal statistical training. A brief introduction to sampling is included in this chapter while more details and sample size calculation are discussed in Chapter 5.

The **third part** is to develop a practical method of collecting, processing, analysing the interpreting the collected data by people who may be untrained statistically. Together with the first two parts which guarantee the correct collection of data in surveys, this part assures that the analysis of comparable data results in similar outcomes.

The **last part** is to draw all these parts together in a practical implementation protocol that will allow simple but reliable data collection.

Each of the parts is discussed in more detail in the rest of this chapter.

2.1 Indicators

Indicators → *Sampling* → *Analysis* → *Implementation protocol*

The first part of this chapter looks at issues relating to indicators. It explores the definition of Vision 21 targets and Millennium Development Goal 7 as the most recent objectives in the water, sanitation and hygiene-behaviour (WASH) sector and reflects on how a consensus on future indicators can be reached. After investigating data collection in the public or the domestic domain it examines basic rights and basic needs to find established variables for measurement. Concepts such as universal, sustainable inclusion and exclusion criteria are clarified in a WASH context after which data collection methods are outlined.

2.1.1 Vision 21 Targets and Millennium Development Goals

Vision 21 was the first document to set water, sanitation and hygiene goals for the 21st century. It has six targets (Annex A table A.1) of which only three[1] are included in this research (Table 2.1).

VISION 21 targets

Nr.	Intermediate targets for 2015	Targets for 2025
1	Universal public awareness of hygiene	Good hygiene practices universally applied
2	Percentage of people who lack adequate sanitation halved [a]	Adequate sanitation for everyone
3	Percentage of people who lack safe water halved [a]	Safe water for everyone

[a] Superseded by Target 10 of the Millennium Development Goals (see Table 2.2)

Source: (WSSCC 2000b,p.35)

Table 2.1: Vision 21 targets one to three including intermediate targets

[1] Data collection regarding V21 target 4 (school-sanitation) was included in this thesis as far as it relates to information on school sanitation collected at the household level.

These three[1] were selected out of six because they were the only targets for which information can be collected through household surveys. Their achievement is envisaged by the year 2025, but intermediate targets have been set for the year 2015 as shown in Table 2.1. Some of the intermediate targets are superseded by the MDG agreed at various World Summits on Sustainable Development (Table 2.2).

Millennium Development Goals

Goal 7: Ensure environmental sustainability;

Target 10: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation;

Indicator 30[2]: Proportion of people with sustainable access to an improved water source.

Indicator 31: Proportion of people with sustainable access to improved sanitation.

Source: (UN 2001b,p.57)

Table 2.2: Millennium Development Goals relating to water and sanitation

The indicators and targets mentioned above are predominantly defined as proportions of people. This means that, as the survey aims to be an individual or a household survey, the data collected at household level will have to result in a simple **categorical** or **dichotomous value** such as the household has (or has not) "access to an improved water source". This implies that the enormously complex reality of service provision or hygiene behaviour will be summarized in a simple *yes* or *no* as the basis for advocacy, decision taking and future actions. The challenging task of designing the indicator is made even harder by the fact that there are no direct means to capture any of these measures of interest through the collection of a single simple piece of data. Measurements have to be found that approximate the measures of interest. These indirect measurements are referred to as **proxy indicators**.

[1] Data collection regarding V21 target 4 (school-sanitation) was included in this thesis as far as it relates to information on school sanitation collected at the household level.

[2] Before the World Summit of Sustainable Development in Johannesburg this was indicator No. 29!

To take an analogy from bacteriology, it is practically impossible to measure pathogenic concentrations of the *vibrio cholerae*, *Salmonella typhi*, and every other currently known disease-causing organism in drinking water or in food on a regular basis. It has, however, become relatively straightforward to measure the indicator organism *E. coli*, and this indicator has been widely successful in advancing the objective of "*safe drinking water*" to promote the value of "*Health for All*" (Kolsky 2002).

Performance indicators are defined in this paper as practical and useful surrogates or proxies for the direct measurement of performance. Most standards are based on indicators, because they can be measured reasonably easily, rather than the performance itself.

Indicators are by definition, "an indication" of status or process rather than the measurement of the status or process itself. Indicators, in particular proxy indicators, are inherently open to debate precisely because they are imperfect surrogates for what they 'indicate'. The question continually asked during the process of choosing indicators is whether the indicator reflects accurately enough the critical aspect of the performance. Universal acceptance of indicators can be reached in different ways. Those considered in this thesis are in order of preference:

1. *Scientific consensus*, in which scientific proof can convince funding agencies and practitioners that the indicators are accurate;
2. *Consultation consensus* in which many of the funding agencies and practitioners agree on the indicator knowing their advantages and limitations;
3. *Influential 'consensus'* in which a critical mass of organisations, or one or more highly respected or key organisations uses these indicators and other organisations follow and use them *de facto*.

A *Scientific consensus* is preferred as it gives an evidence base which can lead to universal acceptance and use of indicators. The *consultation consensus* can be achieved even when there is no evidence base but requires usually a large and lengthy process of consultation before indicators become accepted and used. *Influential' consensus'* has the advantage that the indicators are universally used as an 'accepted' standard but carry the risk that despite their use they have no solid scientific footing or are experience based.

This thesis aims to find a consensus at all levels by finding a scientific footing for the indicators being developed, consult widely among stakeholders who would use these indicators and work in collaboration with influential organisations, such as UNICEF, World Health Organisation (WHO), World Bank (WB) and WSSCC. The level of consensus achieved and required in relation to the further development of the survey methodology will be discussed in the last chapter of this thesis.

Ultimately, we are concerned with indicators because we seek a practical way to obtain relevant data about performance on which to base decisions.

Indicators will have to measure access to water, sanitation and hygiene behaviour at the household level. Each indicator has to be defined in such a way that it becomes measurable. This will be done in detail in Chapter 4. The rationale for measuring these indicators will largely determine how they are measured.

2.1.2 Public versus Domestic domains

Research findings suggest that as neighbourhood levels of faecal contamination improve, the conditions and practices within households become more important as determinants of disease transmission (Cairncross 1996). This means moving away from the traditional, engineering approach to environmental health through large centralised systems of infrastructures. It brings the focus towards *private* health at household level. The concept of the *domestic domain* encompasses the space within which the decisions and actions are taken at household level and their relation to environmental health, and is distinguished from the *public domain* in which the intervention of public authority is required to prevent disease transmission. This model acknowledges the importance of household practices and behaviour. It justifies the choice of the household as the basic level of data collection, as explained in more detail below in paragraph 2.2 on Sampling.

2.1.3 Basic rights and basic needs

This paragraph explores how the basic rights and basic need literature defines access to water and sanitation as a basis for defining indicators. There are two major lines of thought in determining what kind and which level of services people should receive and why. One line of thought is based on what people need while the other is rights-based in the form of international, national and local law. International recognised rights can be the basis of a legal obligation to ensure services such as water and sanitation. Defining basic needs rarely go further than forming moral obligation for service provision. While defining needs can form the basis for legislation, and therefore links needs and rights, both approaches can be used independently.

The reason for looking at these approaches in relation to WASH indicators is that the description of existing needs and rights could provide a useful starting point for defining indicators used to measure access to water and sanitation. Incorporating these in new indicators not only brings newly designed indicators in line with existing rights and needs but benefits from an existing consensus on some aspects of these indicators as examined in Chapter 3. The following paragraphs examine how measurable aspects are documented in basic needs and rights literature; but they do not aim to discuss either approach.

Basic rights

Claims to rights to water and sanitation services are mainly based on two international documents. The first is article 25 of the Universal Declaration of Human Rights (UN 1948) which states in its first paragraph "*Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control*". The second is article 12 of the International Covenant on Economic, Social and Cultural Rights (UN 1966) which states in its first paragraph that "*The States Parties to the present covenant recognize the right of everyone to the enjoyment of the highest attainable standard of physical and mental health*". The second paragraph of the same article goes in more details on what steps should be taken to achieve this. In both cases the right to water and sanitation are implicit: neither of the documents mentions the word 'water' or 'sanitation'. Hygiene is only mentioned once in the second document under article 12, paragraph 2b which refers to "*...all aspects of environmental and industrial hygiene*" rather than personal hygiene. Other parts of the Human Rights Treaties refer more explicitly to water issues such as:

- Article 14 paragraph 2(h) of the Convention of the Elimination of All Forms of Discrimination Against Women referring to adequate living condition for rural women "*...particularly in relation to housing, sanitation, electricity and water supply...*" (UN 1979);

- Article 24 paragraph 2(c) of the *Convention on the Rights of the Child* which aims "*...to combat disease and malnutrition,...through the provision of...clean drinking-water...*" (UN 1989);
- Article 14 paragraph 2(c) of the *African Charter on the Rights and Welfare of the Child* which in a similar way wants to "*...ensure the provision of...safe water*" (OAU 1990);
- General Comment 6 on "*The economic, social and cultural rights of older persons*" relates standards of living regarding water to "*...to the independence of older persons,...who...should have access to adequate...water...*" (UN 1995a).

Despite various level of ratification by different governments, there are virtually no enforcement mechanisms to promote binding and enforceable rights under national laws, as a step towards filling the gaps in water and sanitation services. The establishment of the International Criminal Court was seen as a way forward in enforcing of international rights on water and sanitation (UN 2002b) but it is doubtful that apart from the court disputing such issues, international law gives it a legal leverage to do so. In most countries such treaties have had little impact (Adebowale 2001). Many consider that non-mandatory (soft law) treaties as such as the Rio agreements are an inadequate basis for effective control of these processes (Adebowale 2001). Still, several countries have adopted water and sanitation rights in their national legislation (Laos PDR 2002; WaterAid 2003).

Until now international law has only been able to create an enabling environment. While governments might want to adhere in principle to some of these international agreements, their reluctance to adopt them in national legislation might be because adoption imposes legal obligations on them.

Water, sanitation and hygiene have each received different degrees of attention in international and national law. These differences will be looked at in the next chapter.

Basic needs

Each individual person needs a minimum amount of water to survive. But that minimum amount of water is hardly the foundation for a meaningful life. Using terms such *basic health* as the principle for defining and quantifying needs increases the complexity as there are no clear definitions for such terms. For goals like sanitation and hygiene behaviour, where there is no initial demand and no perceived need, *basic needs* become even harder to define. Needs approaches tend to be a process of quantification of minimal needs, usually disregarding factors such as dignity as they are even more difficult to quantify.

Such problems could be avoided by concentrating on water and sanitation approach as a basic right rather than defining a minimum need as mentioned in the former paragraph. However making the right to water and sanitation explicit begs the questions of definition. How much water of what quality do individuals have the right to (Calaguas 1999; CESR 2002)? This question, among others, reveals that the needs and rights approaches are intertwined. In the next chapter, a similar relationship can be demonstrated for each indicator.

2.1.4 Universal versus context-specific indicators

For the MDG, the use of indicators focuses on comparisons over time to measure progress and in space to make spatial analysis and encourage competition. To make such comparisons meaningful, the indicators have to be comparable. International bodies like the UN look for universally accepted indicators to facilitate this comparison process. However practitioners on the ground, who generally are involved in the data collection, see little incentive to collect data which are non-context specific and which only serves the national and international reporting process. This dichotomy exists between Vision 21 and the Iguaçu Action Plan as well as in each document in itself. According to Dr. P. Gleick in Vision 21, "*reliable monitoring will depend on greater efforts to standardise definitions, to improve data collection and expand reporting to all countries*" (WSSCC 2000b). However, in the same document WSSCC also underlines the need for "*specific indicators*" and maintains in the same chapter that "*No universal standard is possible, due to the social or environmental differences*" (WSSCC 2000b). The later quote is more in line with another observation that "*Existing progress in identifying indicators needs to be reinforced and also made more sensitive to the monitoring requirements and of people themselves*" (WSSCC 2000b).

To ease this dichotomy, the developed *WaSH*[1] method has different levels of data collection in the survey methodology. While standardised data are collected for nationwide and international comparison, other data could optionally be collected which are context-specific and more useful locally. Thess additional data could mean that different definitions could be used to measure similar performance.

Take for example, the *WaSH* definition to access which includes *type of source* and *collection time* while the local definition might be *distance* and *use of small neck collection vessels*. Data to examine access will be in the core of the survey while data required for local definition can be added to the questionnaire. Using different definitions to calculate access figure might give different access figures in for the same area but this should not pose a problem as long as the figures are accompanied by the definition used. For this the methodology suggested in this thesis would have three levels of data collection:

- *Core* data collection;
- *Optional* data collection;
- *Additional* data collection.

Core data collection results in the minimum data required to form the core indicators. The core indicators form the part of the survey which results in 'universally accepted' indicators for national and international comparison. The data and indicators at this level would be as independent as possible from the context.

Optional data are data on which there is some agreement[2] but which is not yet standardised. It is mainly needed for further development of core questions or for generating extra information of interest. But it is not required to obtain the core indicators. This would allow more flexibility while not affecting the *core* of the survey data.

Additional data are required for the constitution of locally-defined indicators and enables data collection effort to be used to accumulate locally required information.

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[1] *WaSH* is used to denominate the survey method developed in this thesis while WASH is used as an acronym for "WAter Sanitation and Hygiene behaviour"

[2] The WSSCC monitoring task force is presumed to become the advocate for the *WaSH* methodology

This thesis is only concerned with the *core* and *optional* questions. It is however also concerned with the additional data collection insofar as the addition of this data collection can influence the data collection of the two other levels of data.

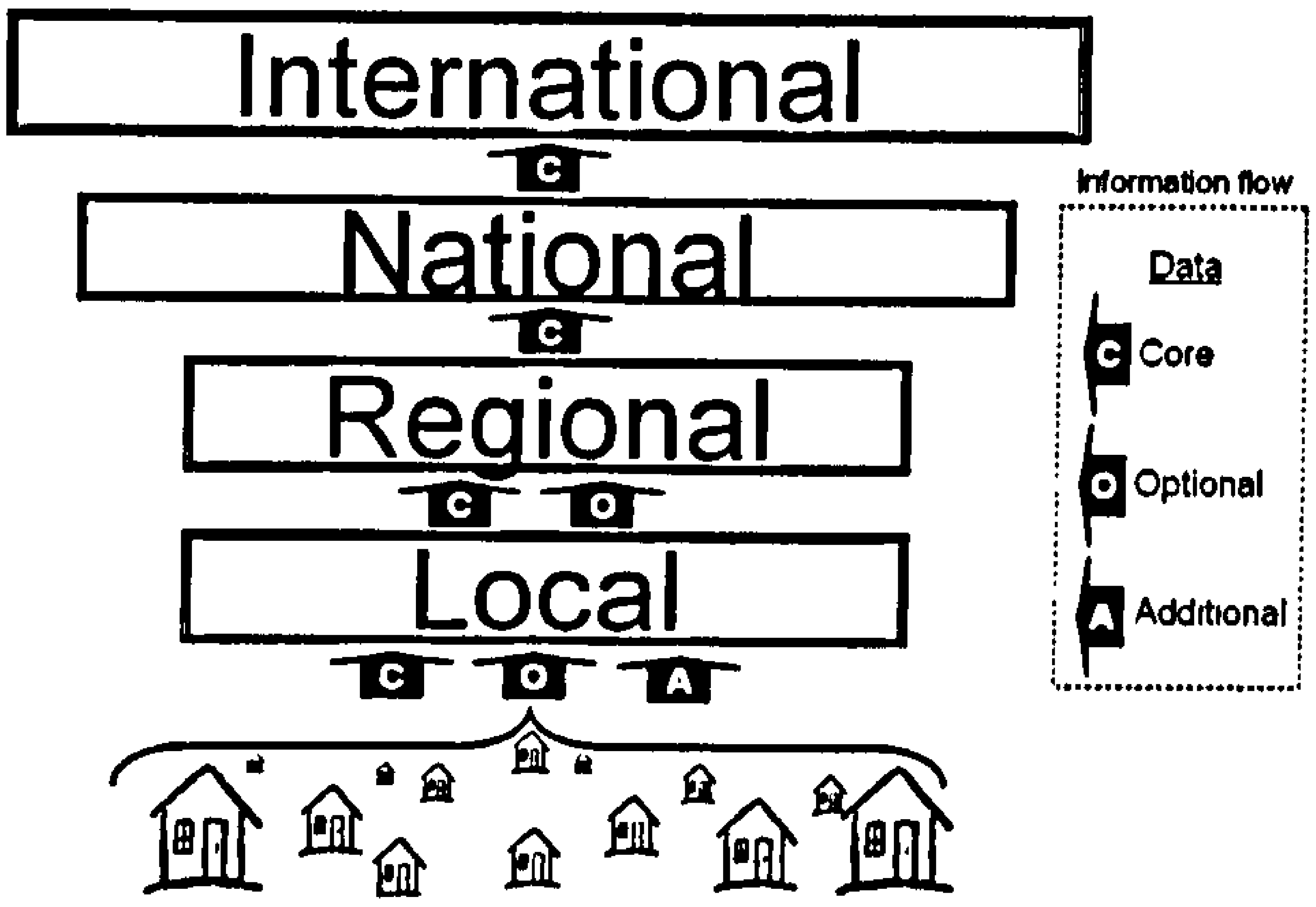


Figure 2.2: Flow of information addressing local to international needs

The flow of this information could be as illustrated in Figure 2.2. Such an approach does not entirely resolve the conflict between universally accepted indicators and specific ones required for local information. For example, qualitative information required at the local level uses distinctively different data collection methods and often does not yield statistically representative data. Such qualitative data collection does not fit well in the *WaSH* surveys, as discussed in Chapter 1.

An approach using different levels of questions would suit the need for universally standardised information required at a national and international level while also contributing to the collection of locally meaningful data required for implementation.

2.1.5 Emic versus Etic definitions of indicators

Linked with universal and local indicators is the need define indicators from an emic or an etic perspective. *Emic*, a term from ethnography, means from the point of view of the persons from whom the information is collected. This is in contrast with *etic* which is from the point of view of an *external* person interpreting the collected data. For example, clear transparent water can look appealing from our etic point of view, as it is more likely to be free of pathogens. An emic point of view could be that is suitable for washing as it is clear and so unlikely to stain clothes, but not suitable for drinking as it has no taste. Etic and emic views are crucial in implementation but could result in a wide range of definitions for access to water and sanitation. The emic definitions of access will vary from place to place but also within one place they are likely to vary over time when circumstances change. Dissimilarities in emic perspectives could hinder comparison in time and space; therefore they can not be taken into account for the *WaSH* survey methodology as a basis for the core questions.

2.1.6 Sustainability

Sustainability is implicit throughout all the MDG goals and explicitly mentioned in Goal No.7 "Ensure **environmental sustainability**". This implicit reference to sustainability is not surprising as no human society has ever consciously promoted its own un-sustainability (Bossel 1999). "**Sustainability**" in Target 10 (UN 2001a) could refer to *sustainable access* as environmental sustainability as well as *continuing access for a long time* (Woodford 2003) which refers to sustainable livelihood. The latter term *sustainable livelihood* was first used as a development concept in the early 1990s. Chambers and Conway defined sustainable livelihoods as those: "*... which can cope with and recover from stress and shocks, and provide for future generations*" (Chambers 1991). So there exist various definitions of sustainability depending to their context, but the most often cited definition can be found in "*Our Common Future*", commonly known as the Brundtland report. It describes sustainable development as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED 1987). Following the Brundtlandt report and Agenda 21 the Bellagio principles were published in "*Assessing Sustainable Development: Principles in Practice*" (Hardi 1997). Measuring environmental sustainability in the sense of maintaining the *Earth life support system* has a time dimension which makes it difficult to recognise in advance the full extent of all possible threats. This makes environmental sustainability as defined in the Brundtland report too ambitious for measurement in a cross-sectional household survey which focuses on water, sanitation and hygiene behaviour.

Many households in the world live in a subsistence economy in which concern about sustainability is focused on the continuation and affordability of the water source or water service provision on which their livelihoods depend, rather than the environment at large. For the purposes of an indicator in a cross-sectional household survey, sustained access can only be defined by factors relating to the household. So for the purpose of measurement, sustained access can be defined as access that can "*be allowed to continue for a period of time*" (Woodford 2003). In the *WaSH* survey, sustainability will be defined in terms of continuity and affordability of access to improved services rather than the environmental sustainability of the human eco-system as discussed earlier. So for the purpose of measuring we could define:

> **Sustainable access**: Reliable access that can be maintained for periods of time, be it technically (e.g. maintenance), affordably (e.g. cost), conveniently (e.g. distance, time).

Box 2.1: Sustainable access as defined for the *WaSH* survey methodology

How to measure this for each of the three *WaSH* indicators will be discussed individually in Chapter 4.

2.1.7 Inclusion and exclusion criteria

Exclusion criteria in this document will be defined as criteria with a high *negative predictive value* (*NPV*) while **inclusion criteria** have a high *positive predictive value* (*PPV*) as defined in Figure 2.3. Two other measures "*sensitivity* and *specificity*" are also relevant to the discussion below.

		True behaviour	
		Do wash their hands.	Do not wash their hands
Measured behaviour	Do wash their hands.	A	B
	Do not wash their hands	C	D

Positive Predictive Value or PPV (%) = A/(A+B)

Proportion of the measured positives that are truly positive.

Negative Predictive Value NPV (%) = D/(C+D)

Proportion of the measured negatives that are truly negative.

Figure 2.3: Calculation of positive and negative predictive values

Sensitivity = proportion of true positives correctly identified as such and is calculated by $A/(A+C)$ while *Specificity = proportion of true negatives correctly identified as such* and is calculated by $D/(D+B)$.

Generally access figures are presented as:

- access to an 'improved' drinking water source;
- access to 'improved' sanitation; or
- application of 'improved' hygiene behaviour.

However non-access or non-application of a particular behaviour is more generally measured. This might not seem important for a binomial variable but it becomes important when interpreting results in the light of imperfect definitions used to distinguish the two groups. Compliance with a certain criterion is a binomial variable which has two values; compliance and non-compliance. Figure 2.4 shows the example of a four question survey determining whether people wash their hands with soap. The first question checks whether people in the household own soap. Those who do not can be safely excluded from the group of hand-washers as shown in Figure 2.4. The first question assumes that it is unlikely that regular hand-washers would not have soap at the moment of the interview. Response to the first question distinguishes two groups of people. On the right, those that have no soap and consequently are classified 'people not washing their hand with soap' in red and on the left a group of potential hand-washers in grey/green. Misclassification of people in the left hand group is likely to be larger than those on the right.

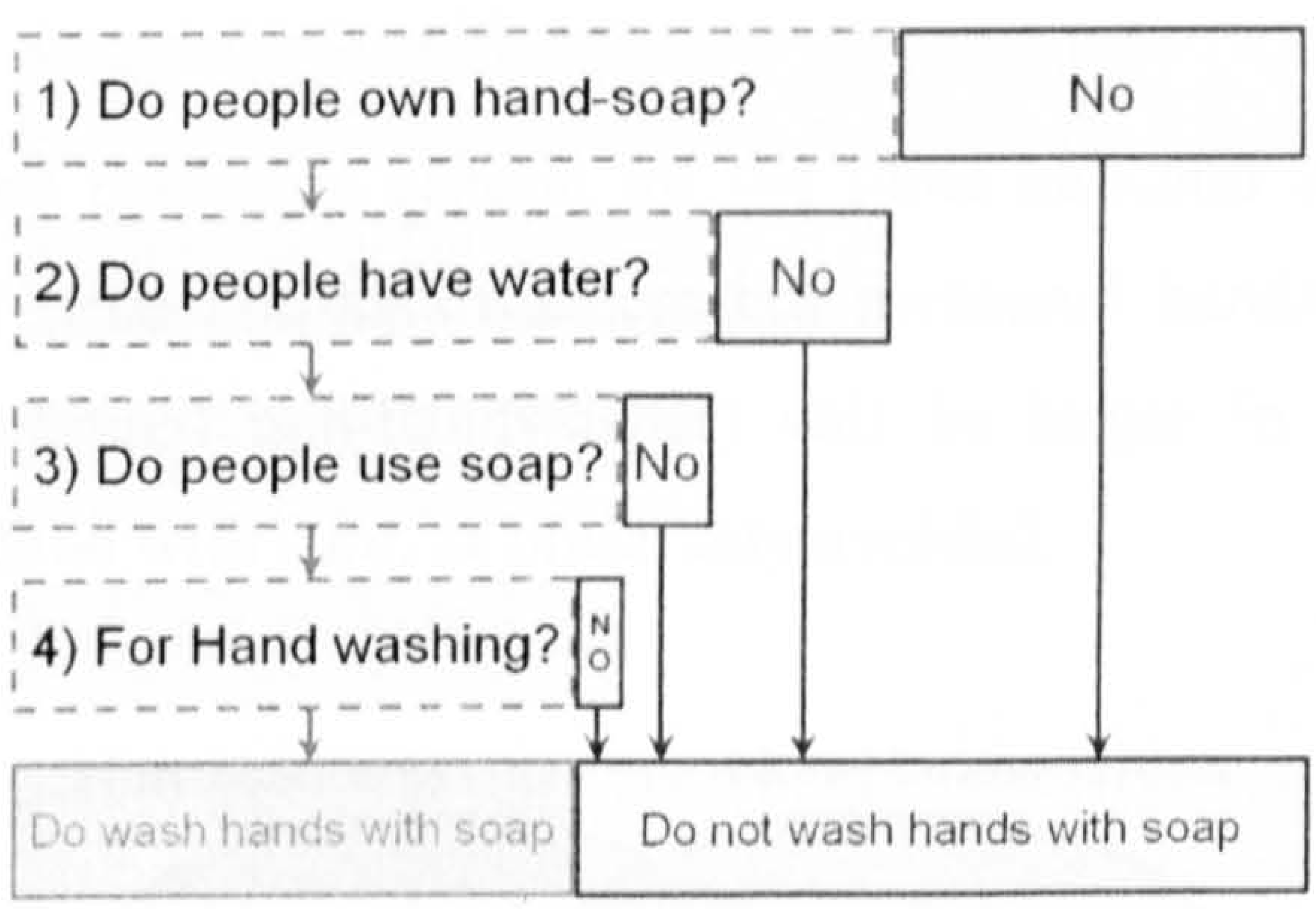


Figure 2.4: Exclusion criteria to determine prevalence of handwashing

The measured non-handwashers in Figure 2.3 can also be found back as group $C + D$ in Figure 2.5. As these 'measured non-handwashers are likely to be true non-handwashers $C + D \approx D$ or $C<<D$ which results in a high $NPV = D/(C+D)$ in Figure 2.5.

Having good exclusion criteria gives little information on the *positive predictive value* $PPV = A/(A+B)$ in Figure 2.5. Positive and Negative predictive values depend on the prevalence of the measure of interest in the population (Kirkwood 2003). These values also depend on the sensitivity and specificity of the measure of interest. A reduced value for C (true handwasher but measured non-handwasher) increases the *sensitivity* of the selection criteria. As C is likely to be small, sensitivity is likely to be high. Sensitivity indicates only the chance that true hand-washer will be measured as a hand-washer, but not say how likely a measured hand-washer is to be a true hand-washer.

There is an inverse relation between sensitivity and specificity which means that indicator with a higher sensitivity tends to have a lower specificity (Kirkwood 2003). This would mean that for the exclusion indicators used in the example we are fairly certain that:

- measured non-handwashers are likely to be true non-handwashers;
- true handwashers are likely to be measured handwashers but
- but not all measured handwashers will be true handwashers.

Mixing inclusion and exclusion criteria for the same indicator makes it difficult to estimate whether B (true non-handwashers but measured handwashers) or C (true handwasher but measured non-handwasher) will be larger in the end result. It therefore has to be done with care, or preferably avoided.

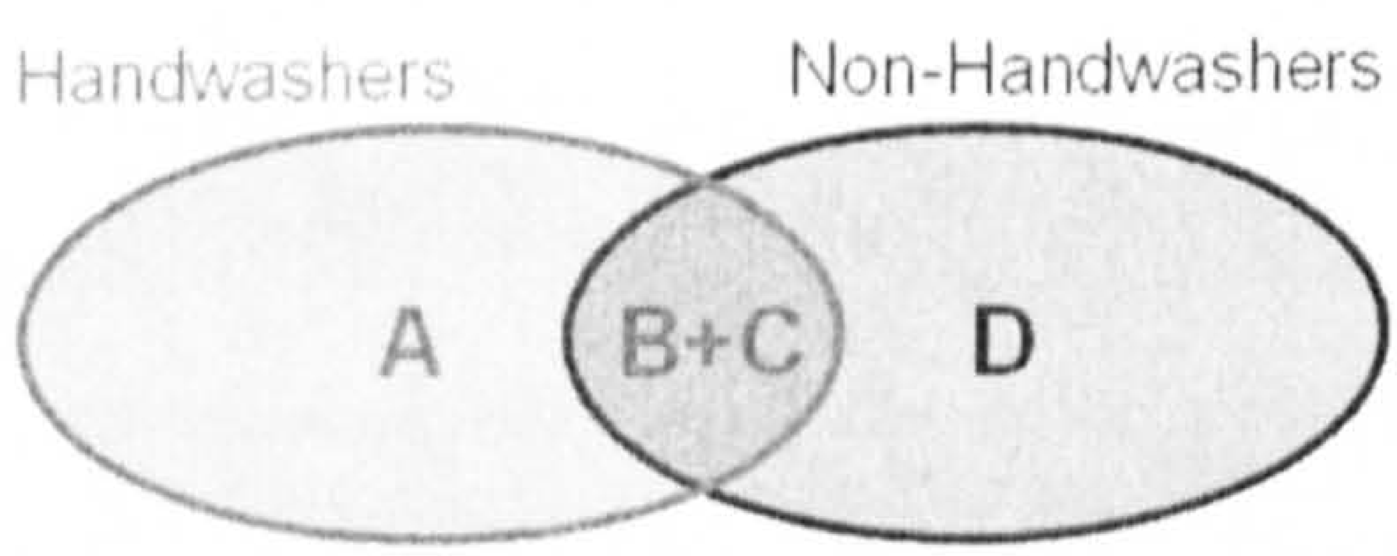


Figure 2.5: Venn diagram on misclassification

It could be argued that when exclusion criteria are used, non-access or non-compliance should be reported but when inclusion criteria are used access and compliance figures should be given. This might seem rather academic when it concerns a binomial outcome. Nevertheless as the goal is to halve the number of people *not* having access to WaSH services, this convention will be maintained in this thesis. It was also the convention used by the Pan American Health Organisation (PAHO) in its "*Regional Report on the Evaluation 2000 in the Region of the Americas*" (PAHO 2001).

2.1.8 Criteria in selection indicators

In the USAID Guidelines for Indicators and Data Quality (USAID 1998) there are two overarching factors that determine the extent to which performance indicators are useful. These are:

- *The degree to which performance indicators and their related data accurately reflect the process or phenomenon they are being used to measure.*
- *The level of comparability of performance indicators and data over various measurement contexts".* Can the measurement be done "*...in a consistent and comparable manner over time and across settings.*

The first guidelines states that (as discussed before) the indicator has to express well all the critical aspects of the measured performance. This requirement needs clear definitions for the measure of interest for each of the indicators before indicators are defined as shown in Chapter 4. Table 2.3 exemplifies the desirable qualities of performance indicators.

Each performance indicator and its constituent variables should:

- Be clearly defined, with concise and unequivocal meaning;
- Allow for a clear comparison with targeted objectives and simplify an otherwise complex analysis;
- Where possible reflect the interest and views of the different stakeholders;
- Be reproducible and easily measurable at a reasonable cost;
- Be understandable, practical and verifiable;
- Represent all important aspects that are statistical significant*;
- Be as objective as possible by reducing to a minimum any personal or subjective appraisal.

* Variables important in defining access but not changing the access figures significantly can be omitted the survey's primary goal is obtaining prevalence figures.

Adapted from (ISO 2005b; Redaud 2005)

Table 2.3: Desirable qualities in an indicator.

The second point relates to the universality of the indicator (also discussed earlier) which allows comparison in time and place.

The information collected to determine the 'value' of the indicator should encompass as much as possible the different aspects of a complex reality. However the more complex the indicator is, the more aspects it will have on which a consensus must be reached between stakeholders.

2.1.9 Access versus use

Institutions such as the WHO[1] and Unicef prefer to report water and sanitation coverage in terms of 'access'. This is most likely because in terms of advocacy, 'non-access' gives a strong signal that people are being deprived of basic services. Access means *the possibility of being able to use*" a certain facility or service (Woodford

[1] WHO and Unicef's JMP collaboration is responsible for reporting on MDG target 7 within the UN

2003). Proximity to a facility such as a toilet could be a possible proxy determining access but it could disregard many other factors such as affordability, cultural and mental barriers for people to use such facilities. It is however use and not merely access to such facilities which is likely to improve the wellbeing of a target population (Mertens 1992). So while non-access is a good concept in terms of advocacy it is a hypothetical indicator and says little on the actual situation. Use is a proof of access even when it is far from an ideal level of access. Use is much easier to measure than access (the potential to use) and is most often measured in surveys. Although not explicitly mentioned most survey measure use of water and sanitation facilities while reporting it as access. For example the JMP measures the use of certain water sources and toilet technologies but reports the result as "access" (WHO/UNICEF 2000, 2004, 2005). In this thesis 'use' of facilities will be reported as 'access'. This is because use of facilities and services is the only proof that there are no barriers to access, which could include availability, understanding, socio-cultural factors or others restricting people from using facilities and services.

2.1.10 Data collection

There are many ways of systematic data collection. Most water and sanitation information relating to 'access' is collected through **questionnaires** (DHS, MICS, LSMS, GHS, ...). Systematic data collection by using **questionnaires** has some powerful advantages over less structured approaches, but also some limitations (Curtis 1993; Pedersen 1994) as shown in Table 2.4.

<u>Advantages:</u>

- Efficiency: simple and cheap to administer;
- Consistency, comparability, generalisation: Standardised formats ensure all respondents are asked the same question;
- Summary and analysis: it provides quantitative data that can be quickly summarised;
- Scientific rigour: questionnaires can be evaluated for reliability, validity and responsiveness.

Limitations:
• Limited depth: cannot generally provide new insight;
• Inflexibility: structured, standardised format is constraining;
• Cannot detect the unexpected;
• Standard questions may be irrelevant, inappropriate or ambiguous in some context eliciting meaningless responses;
• Error and bias in questionnaire design, administration and response

Table 2.4: Advantages and limitations of questionnaires in environment health studies.

There are two major types of questions, the **open-ended** questions in which any answer can be accepted, and **closed** questions in which the range of possible answers is limited. In a summative survey, open-ended questions would result in more information than required. The format of the information would not allow for straightforward summative analysis without some interpretation of the responses. It would also require the staff doing the interviews to develop more skills for the staff doing the interviews. For these reasons open-ended questions are not considered in the *WaSH* survey methodology. For questions which might cause discomfort or stigma, **observations** are considered more reliable than questionnaires as interviewees are not able or willing to answer questions truthfully (Bentley 1994; Clemens 1987; Curtis 1993; Huttly 1994; Manun'Ebo 1997; Stanton 1987).

Observation requires a surveyor to enter a place where behaviours or situations of interest are likely to be seen, and record the nature and frequency of these observations. There are different forms of observational studies (Almedon 1997) such as:

- **Extended or unstructured observation,** when all that is observed is written down and analysed afterwards;
- **Structured observation,** when pre-selected things are observed, (often resulting in certain behaviours being counted rather than described);
- **Spot observation,** the simplest form which looks at one particular and easy to observe items (Such as the presence of soap) which can be a proxy for the behaviour of interest (e.g. the use of soap).

Unstructured observations, like open ended questions, result in more information than required and give information in a format which is difficult to distil into a summative outcome. Structured observation goes some way towards making the information more readily analysable, but the use of **structured observations** in environmental health studies has both advantages and limitations as shown in Table 2.5.

<u>Advantages:</u> • Information on the physical environment and human behaviour can be recorded • Observer can 'see' what the untrained eye can miss, as he/she is focussing on the issue. • Information can be collected on people that cannot take part in interviews, such as babies. • The information can be checked against other sources, e.g. claims of behaviours in interviews can be checked with observed behaviours <u>Limitations:</u> • Observation may not be possible because of social constraints or because the behaviour to be observed is rare. • Behaviour may change due to the presence of the observer. • Behaviours can be correctly recorded but misinterpreted through the observer. • It is time consuming and therefore expensive • To increase accuracy there is an opportunity for repeated observations (Gorter 1998) • The first day of observation is more reactive than observations on later days (Gittelsohn 1997).

Table 2.5: Advantages & limitations of structured observations in environmental health studies.

The biggest disadvantage of structured observations is the time needed to do them. This makes them less suitable for a cross-sectional survey. The most suitable observation for the *WaSH* survey methodology will be **spot-observations** made by the interviewer during the interview.

The spot-observations of behaviours or physical characteristics chosen will only be useful when there is a high probability of observing them during the interview. Spot-checks in the case of V21 assessments will observe signs of behaviour rather than the behaviour itself, because it is unlikely that the behaviour will occur during the short period that the interviewer is present in the household.

An interviewer can also prompt an interviewee for a demonstration. Table 2.6 shows the advantages and limitations of using **demonstrations** in health surveys as a possible alternative to spot observations.

Advantages:

- Can be prompted by an interviewer.

Limitations:

- Can be time consuming.
- Result might not be representative of day-to-day practice

Table 2.6: Advantages and limitations of demonstrations in environmental health studies

Pocket-voting is a way in which people can respond to questions such that nobody else (including the interviewer) knows the given answer, as shown in Figure 2.6. Pocket voting assumes that people know the answer and are willing to give it when they can do it anonymously. It is usually done at community level (van Wijk 2001) but has been used at household level (Cairncross 2005).

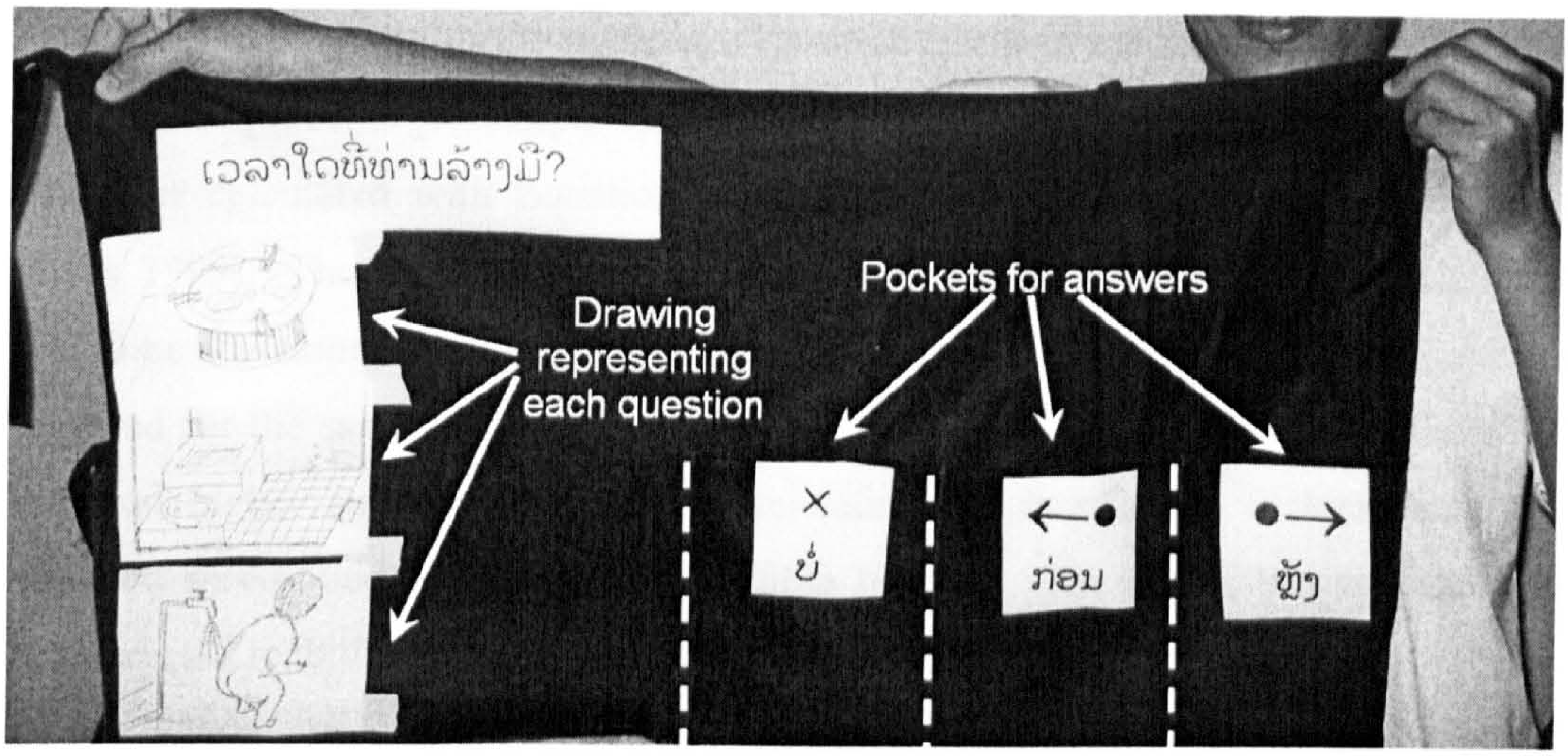


Figure 2.6: Pocket voting as used in the Lao survey

The last method considered for the *WaSH* survey is **randomised response technique** (RRT). As with observations and pocket-voting it was developed to avoid an excess of refusal or misleading responses when obtaining information which could be embarrassing or threatening. In randomised response the respondent is given two questions; a sensitive question and an innocuous question. Chance determines which question the interviewee answers while the interviewer is unaware to which question the answer is related. To determine what the prevalence of answers are; suppose a simple example of RRT with question *A* the sensitive question which has an unknown probably P_A of being answered 'yes' and question *B* a non-sensitive question which has know probability P_B of being answered yes. The interviewer knows only the prevalence P^* of 'yes' answers as he does not know which questions were answered by each of the interviewees. Equation 2.1 allows estimating the prevalence of yes answers on sensitive question *A*.

$$\hat{P}_A = \frac{P^* - P_B(1-\theta)}{\theta}$$

(Warner 1975)

$\hat{P}_A$ Estimated probability of yes answers on sensitive question *A*

P^* Prevalence of mixed answers as given to the interviewer

P_B Known prevalence of yes answers on the non-sensitive question *B*

θ Know probability of question *A* being drawn.

Equation 2.1: Calculation of estimate prevalence using a simple randomized response technique

Because the responses to the innocuous question result in redundant information this approach requires larger sample sizes to meet the required confidence intervals. The estimates calculated with Equation 2.1 can on occasion result in negative values (Levy 1999). This method was considered for testing in the *WaSH* survey trials but had to be abandoned due to the large sample size (calculated in Chapter 5) which was required for the survey trials. Increasing the sample size in order to apply the RRT required higher sample sizes than those calculated in Chapter 5, increasing the required survey budgets above the available funding. The use of this method also contradicted with the philosophy of a small and simple survey methodology.

2.1.11 Measuring Health benefit

People's wellbeing is often the stated objective of policies regarding water, sanitation and hygiene behaviour. However such wellbeing is too often seen very narrowly as just health or more precisely the absence of disease. With health benefits an important driver for water and sanitation programmes (see Figure 2.7a) there have been regular attempts by funding and implementation agencies measuring health changes to relate them to water and sanitation interventions (Cairncross 1999) as shown in Figure 2.7b. So instead of monitoring access and practice why not measure changes in health?

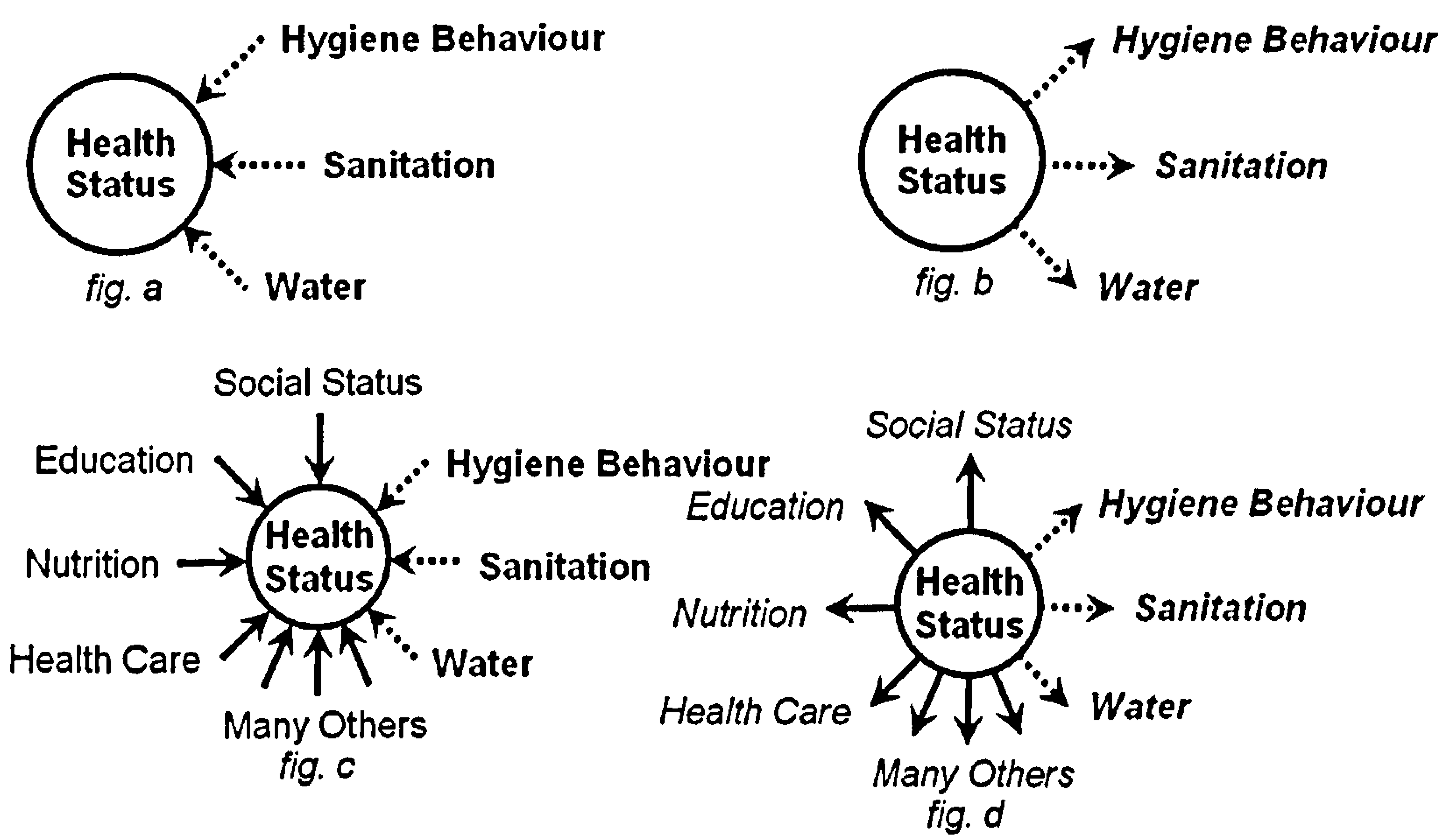


Figure 2.7: Relation between water, sanitation, hygiene-behaviour and health status

While water, sanitation and hygiene behaviour often have a considerable impact on health there are many other aspects determining people's health status as shown in Figure 2.7c. These various determinants of health and their complex interactions make it difficult to relate changes in health status unambiguously to water, sanitation and hygiene promotion projects (Figure 2.7d).

In the past many people have tried to establish a causal link between projects and health. Lack of meaningful results despite huge cost and efforts involved in the studies led a panel of experts to conclude that an organisation such as the World Bank should not undertake or invest in any long-term longitudinal studies for the purpose of measuring health impacts (World Bank 1976). Even techniques developed later such as the case-control method (Baltazar 1988; Briscoe 1985) showed similar flaws as with longitudinal studies. A critical review by Blum and Feachem of existing studies aiming to attribute health benefits to water and sanitation interventions, listed eight common shortcomings in methodologies used in existing health impact studies (Blum 1983). The paper listed:

1. Lack of adequate control;
   Without adequate controls it is impossible to compensate for changes that happen in the community regardless of the intervention.
2. One to one (village) comparison;
   Interventions and controls in one defined group of people do not allow to distinguish whether changes are due to changes in some typical aspects of each group or simply to an epidemic.
3. Confounding factor;
   Factors having an effect on the intervention and the outcome simulating a causal relation.
4. Health indicator recall;
   Not everybody is able or willing to state their health status accurately.
5. Health indicator definition;
   Not clearly defining what the case definition is of an health indicator such as what makes a diarrhoea case.

6. Failure to analyse by age;
   Young and older people often have different behaviours and susceptibilities which has to be accounted for in the study.
7. Failure to record usage;
   It is the proper use of facilities such as toilets that will have an impact, not just owning one.
8. Seasonality of impact variables;
   Most water, sanitation and hygiene related diseases are seasonal in large parts of the world.

Some factors listed above, such as problems of recall, definition of indicator and correct usage of facilities, will be important factors to be take into account when designing a cross-sectional survey methodology.
A more important reason not to focus on direct health benefits is that such an approach ignores other secondary benefits which might outweigh the direct benefits such as time saving and convenience (Cairncross 1999). Health is after all only a small part of wellbeing.

2.1.12 Minimum Evaluation Procedure

The difficulty of attributing health benefits to water and sanitation programmes led WHO to define Minimum Evaluation Procedures MEP (WHO 1983). These procedures acknowledge that water and sanitation projects go through different stages before health benefits can be achieved. The principle of MEP is a more holistic approach to monitoring by not only looking at the impact but also examining each of the links in the causal chain (Figure 2.8), especially functioning and use. It recognised that correct use of facilities and hygiene behaviour are important factors in achieving health benefits.

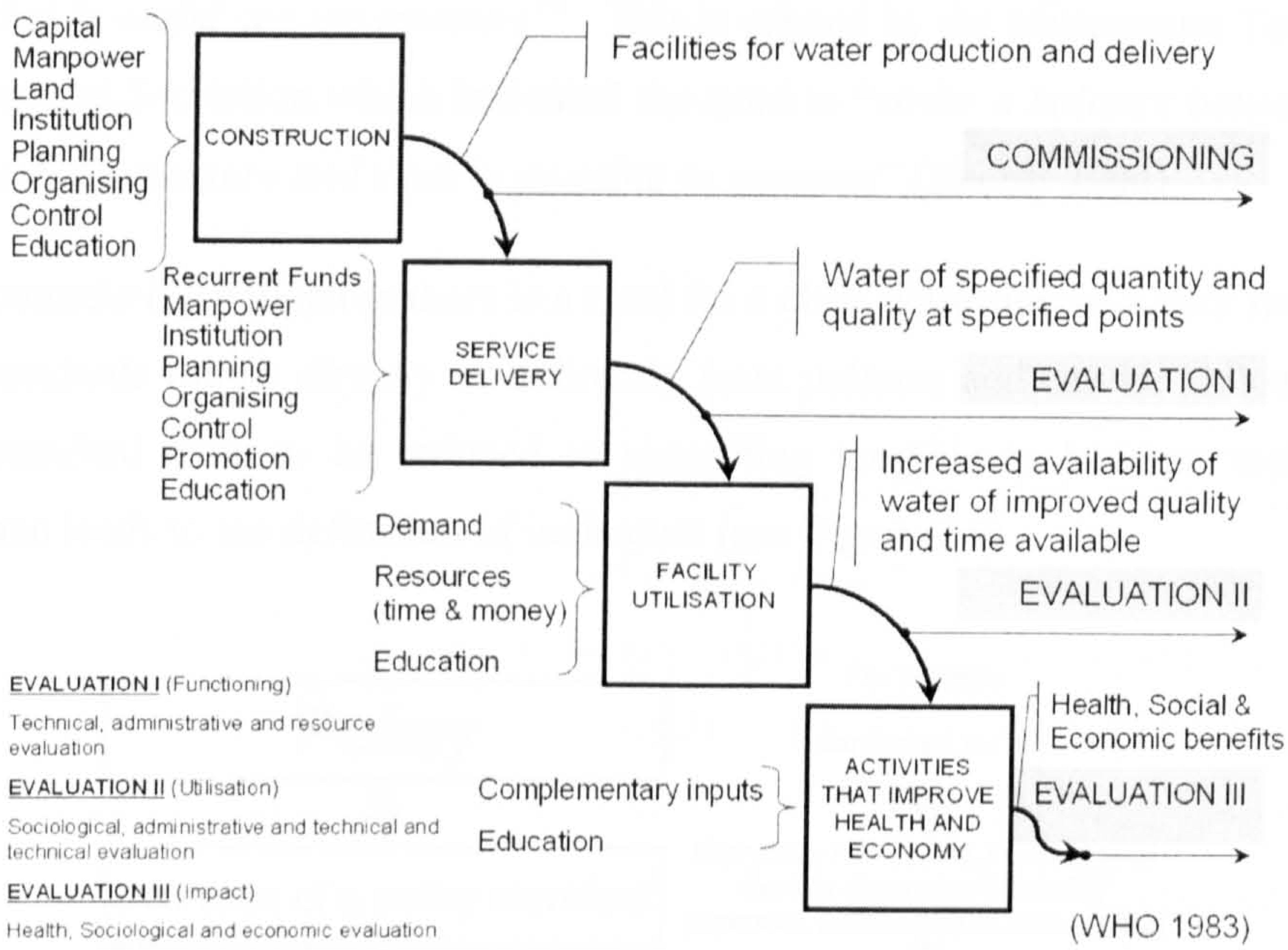


Figure 2.8: WHO's minimum evaluation procedures (MEP)

This approach is quicker and cheaper than epidemiological studies and can be integrated at the project design stage. Since its focus is further back up the causal chain, it is easier to attribute outcomes to the project intervention. Evaluations have far greater diagnostic power, indicating opportunities for project improvement. This approach will not only help to establish a baseline yardstick against which to compare evaluation results, but also to improve project design. While a logical approach for formative project evaluation, MEP is not a useful alternative to the summative cross-sectional survey design developed in this thesis as the *WaSH* survey focuses on the functioning and use at the time of the survey.

2.1.13 Defining the indicators

Water, sanitation and hygiene related surveys often contain questions of interest, but seldom is each question clearly related to a goal or outcome. Often collected data proves to be less useful after collection than it seemed before collection while simple information useful for analysis was not collected. "*Collecting information without any clear purpose or failing to use collected data is a waste of resources, money and staff time as well as other people's time, including that of the target population*" (Bostoen 2005). Moreover to paraphrase Einstein, "*Not all we can measure is useful,* *not all that is useful can we measure*[1]". This is echoed by the Millennium Task Force for Water and Sanitation which indicated the need to "*strike a balance between what is desirable to measure and what is possible to measure*" (Shordt 2004).

Before considering indicators there is a need for a clear definition of *policy standards*. These standards follow directly or indirectly from policies and can be philosophical. Policy standard have to be reduced to something tangible to become measurable which then leads to the definition of indicators (see Figure 2.9).

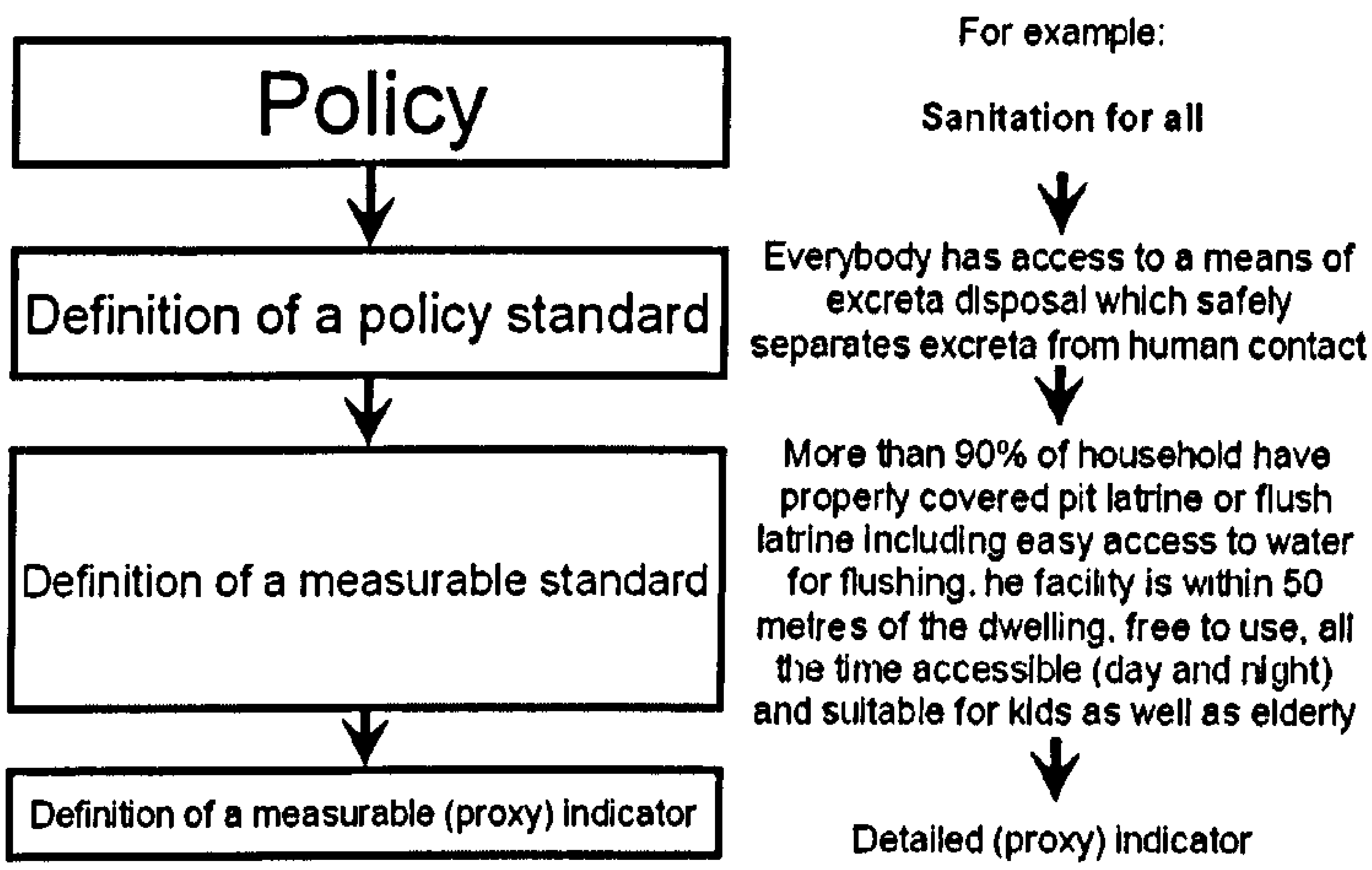


Figure 2.9: Relation between policy and measurable indicators

In the WASH sector there is often confusion when setting indicators between indicators as a tool for measurement and policy standard. The sector has no accepted definitions of what constitutes access to water or sanitation. This lack of policy standards not only complicates setting indicators for measuring access but also put great responsibility on those defining the indicators. Without clear standards there is the risk that indicators created as a tool for measurement become the *de facto* policy standard.

The risk of setting indicators in a field with no clear policy standards is that (imperfect) indicators for measuring become unsuitable policy standards.

[1] Original quote by Einstein: "*Many of the things you can count, don't count. Many of the things you can't count, really count.*"

In terms of the three indicators of interest:

- Access to an 'improved' drinking water source;
- Access to 'improved' sanitation;
- Application of 'improved' hygiene behaviour.

there is no single piece of information that fully describes all the critical aspects of any of the above indicators. This means that several different pieces of information need to be collected in the form of variables to make up the various components of each indicator. While water, sanitation and hygiene behaviour are interlinked, their indicators should be as independent as possible. This means for example, that lack of water or an excreta disposal facility should not automatically result in a negative assessment of 'improved' hygiene behaviour. Each of the three indicators will be discussed in more detail in the next two chapters.

2.2 Sampling

Indicators → *Sampling* → *Analysis* → *Implementation protocol*

The population targeted by a survey will be determined by inclusion criteria within administrative boundaries or geographical locations. To calculate the proportion of households having access to water, sanitation or adhering to certain hygiene behaviours, information is ideally required from each household of the population. However collecting data from every single household is often impractical or impossible, so that data are often obtained from a subset (sample) of all the households (population) from which information is required. The information obtained from analysing the sample will only be valid for (can be inferred to) the population when the initial sample taken is representative for the selected population. In this document 'population' is used in its statistical sense as the collection of *all the basic sampling units*.

2.2.1 The basic sampling unit

The basic sampling unit (BSU) is the individual member of the population whose characteristics we want to measure. In a household survey the individual household is normally the basic sampling unit. However Vision 21and MDG indicators 30 and

31 are expressed in percentages of people, not of households. The choice of the household over individuals as BSU has several advantages. Households are generally based in a dwelling. They are relatively easy to define as they have a fixed geographical location and in the best case a unique identifier such as an address. This allows them to be listed and traced back after selection from a list. Individuals on the contrary are more difficult to identify as they are more mobile and are more difficult to find if they are not linked to a dwelling. In a given period of time, less variation is to be expected in a list of dwellings than in lists of individuals living in those dwellings. In other words, lists of dwellings vary less over time compared to individuals.

There are disadvantages to household surveys however. Choosing households as a BSU assumes that households have each a similar demographic structure with similar numbers of members. When the variation in the number of people per household is associated with the measure of interest, the chance of unrepresentative sampling will increase. Some corrections can be made by adjusting the weight but this complicates the process of analysis and cannot fully compensate for all sample errors (see Chapter 5).

The problem in sampling households is that public places and services such as sanitation in public places are left out of the equation. Vulnerable people such as children under 5 years old and the elderly spend most of their time in the private domain (see section 2.1.2 page 40) which gives justification for the use of households as the basic sampling unit.

Taking the households as BSU also assumes that the measure of interest can be collected at the household level as something or somebody is representative for the household. Definition and representation of the household is discussed in the following paragraphs.

Early drafts of the *WaSH* survey also involved data collection from primary school children. Most of these data was to be collected in specific school surveys and as such falls outside the scope of this thesis, but some can be collected during the household survey (Cairncross 2001). Although part of separate analysis the data collection was part of the household survey. For this seperate analysis the basic sampling unit was each school child found in any selected household, attending school daily and within the last two years of primary school system. While the school surveys aim to collect information on hygiene education and sanitation at school, the two last years of primary education are more representative for the presence and achievements of such a programme than interviewing all students. The reason for collecting such information at the household level was that it had been argued by some observers that that school children would be more truthful in answering questions on hygiene and sanitation at the household level than under the watchful eye of their teachers (Cairncross 2001). Early on in the development of school indicators, the feasibility of interviewing schoolchildren at the household level proved challenging and the interpretation of the data complicated. Information on the presence of schoolchildren was included in the survey to demonstrate this effect to the different institutional partners collaborating in the project as to not compromise the institutional consensus as discussed in paragraph 2.1.1.

2.2.2 Defining the household as basic sampling unit

According to Casley (WHO 1983,Annex 1) a universal definition of the household is "*A household comprises a person, or group of persons, generally bound by ties of kinship, who live together under a single roof or within a single compound, and who share a community life*". Another definition for households in rural areas according to the WHO's Minimum Evaluation Procedure for WASH projects is "*A unit which consumes what it produces*" (WHO 1983). The term household may be interpreted according to local conditions; however a convenient definition could be "*those whose food is prepared by the same person*" (Bennett 1991) or "*those who slept in the same building last night*". Using definitions based on meals, it will important to determine which meal of the day is most likely to be the most representative as a household gathering.

These definitions might still pose problems for households such as the increasing amount of single (mostly man-only) households in urban slums or for those not having a house or a place-to-live as dwellings are used for initial identification of households. People such as the homeless, transient or military without any physical address might for that reason not be represented adequately in such as sample. It might be necessary to choose the best or most practical operational definition and think of the limitations and possible problems with it. This should give an insight on how the choice of a definition might influence the outcome in a given situation.

Imagine that families are defined by their primary home which they share as an extended family. These primary homes have all tap water and so 100% of the households have access to water. However at the time of the interview only grandparents with their grandchildren stay at the primary home while absent parents stay in seasonal shelters when working their fields, consuming surface water. Using places were people slept last night as definition of a household, would have required listing these seasonal shelters and resulted in half of the households listed not having access to water.

2.2.3 Representation of the basic sampling unit

Who in the household will give the information that is most representative for the household? Women have been traditionally at the practical day-to-day centre of the household. They are usually involved in the collection of water, preparing the food, taking care of the children and maintaining cleanliness in and around the dwelling. In low income countries they are often at home during the day. So they seem to be the most suitable candidates to interview. Having a woman at home during the day assumes that there is in most cases a traditional family constitution. In some cultures, interviewing women might not be straightforward. Particular in regions that obey a strict purdah, a custom, in some Muslim and Hindu cultures of women not allowing their faces to be seen by men who are not their relatives, either by staying in a special part of the house or by wearing a covering over their face.

With so many responsibilities, women might not always be available to give information and this might increase the non-response rate. Another suggestion is that the person involved in the cooking, cleaning and collecting of water for the household should be interviewed. It is assumed that this person will generally be the 'woman of the house'. Issues involved in representative sampling will be discussed in more detail in Chapter 5.

2.2.4 Participatory methods of data collection

Representative sampling as a statistical process is not the only way of collecting valid data. Vision 21 advocates participatory data collection methods. Introduced in the early 1980s, participatory methods are widely used. The methods range from SARAR, PRA1, RRA2 and DELTA3 to VIPP4, LPSAs and PHAST, to mention but a few. The common factor in all is seeking to empower communities. They are non-didactic while most methods use tools and techniques to stimulate participation.

Their similarity makes it difficult to identify distinctive differences between the various approaches.

In conceptual terms, participatory methods are generally well understood (Almedon 1996; van Wijk 2001). They are widely viewed as communication processes that are learner-centred rather than aiming to achieve defined objectives. Participatory methods are being used in diverse development sectors. Other than hygiene, health and sanitation promotion, the methods are applied in poverty alleviation, agricultural research and extension, community wildlife and environmental management (Buckland 1993; Ludwig 1988; Thomas 2002). While V21 advocates for participatory processes, these approach conflicts with the rigorous standardisation advocated in the same document. Participatory data collected is according to emic approach definitions which will, as in any emic process, vary from community to community (see also paragraph 2.1.5). This will make it difficult to find comparable data, and could limit their use. Some effort has been made to make participatory data comparable (van Wijk 2001) but this results in such complicated and expensive methods that these approaches were not considered for the *WaSH* survey. This does not mean that developments in participatory methods should not be considered in future.

2.3 Analysis

Indicators → *Sampling* → *Analysis* → *Implementation protocol*

Agreement on how to collect the data is by no means a guarantee that surveys collecting the same data in the same way will result in the same conclusions. As mentioned before, no single piece of data can describe fully all the critical aspects of any of the indicators, so the data will have to be combined to obtain values for the indicators. The way individual data items relate to an indicator will be discussed in theory in Chapter 4. Once the value of each indicator is unambiguously determined for each household, statistical analysis will determine the different coverage figures for the sample. The way the sampling process was designed is important in determining these coverage figures, as will be explained in Chapter 5. Taking account of the sample design into the data analysis is referred to as design-based analysis (Levy 1999). Proper analysis will allow inference of the sample's properties to the population represented by the sample. The different steps in the analysis, from preparing and cleaning the data to practically building the indicators from the available data, alongside statistical analysis of the resulting data will be briefly covered in Chapters 4 and 5.

2.4 Implementation protocol

Indicators → *Sampling* → *Analysis* → *Implementation protocol*

For the *WaSH* method to be popular it must be accepted by the international water and sanitation community as authoritative; it must also be convenient to implement by its intended users. This requires clear protocols and guidelines allowing people to adhere to the conditions and the methodologies defined in the first three steps. During the research it was found that the importance of this aspect cannot be overestimated, as will be discussed in Chapter 9. The convenience of implementing a survey methodology will contribute not only to popularisation of the methodology but also to reliable outcomes resulting from the surveys. While implementation with regards to accuracy of the outcomes will be discussed in this thesis, the process of ensuring acceptance and the drafting and dissemination of guidelines will not.

CHAPTER 3 EXISTING DEFINITIONS AND INDICATORS

The previous chapter looked at various aspects relating to the *WaSH* survey methodology. It also divided the study up into constituent parts of which the first consisted in defining indicators for access to 'improved' water, 'improved' sanitation and 'improved' hygiene behaviour.

This chapter is the first of two chapters that will examine these indicators. In this chapter, current definitions are presented, before the indicators are discussed from the viewpoint of three approaches: international rights, existing guidelines and standards, and basic needs. The first approach regards international law and its definition of access to water and sanitation as a right. The second examines how current standards and guidelines define access and practice relating to water and sanitation. The third approach sees access to water and sanitation as a recognised need as documented in literature. The chapter then argues that the above approaches by themselves do not provide enough information as a basis for measurable indicators.

3.1 Defining the Water Indicator

There is no universally accepted, easily measurable definition for assessing access to water and sanitation even after decades of work carried out to improve water and sanitation coverage, because defining such indicators is not as straightforward as it seems. Water plays a vital role in many daily activities. While individual relationship between water and wellbeing are often well understood, the complex interaction of various activities and use of domestic water are less clear and can result in some counter-intuitive relations. The following sections aim to define a water indicator for the purpose of measurement on the basis of existing targets, goals, laws and standards on which a large consensus already has been reached.

3.1.1 Definitions of water targets and goals

The first step in defining *WaSH* indicators is to establish how these indicators have been defined in the past. The first definition by the JMP for "*safe water coverage*" published in 1993 was: "*...proportion of population with <u>access</u> to an <u>adequate amount</u> of <u>safe</u> drinking water located within a <u>convenient distance</u> from the users dwelling*" (WHO/UNICEF 1993). The same document noted that actual definition of the underlined words in more detail (i.e. 'access', 'adequate', 'amount', safe') should be done on a national level (WHO/UNICEF 1993).

The third intermediate Vision 21 target (Table 2.1 page 37) defined the target as the "*percentage of people who lack safe water halved*" by 2015 (WSSCC 2000b). Although not explicitly stated, the Vision 21 indicator suggest that '*lack*' in the target might indicate a concern for quantity, '*safe*' might relate to water quality, reliability of the water source in terms of delivery or even safe access to the source. It is important to note that Vision 21 looks at '*water*' for personal use in general and does not centre on water for a particular purpose. This is in contrast with the MDG which focuses on '*drinking water*'. In terms of intermediate water targets Vision 21 is somehow superseded by the Millennium Declaration, on which the MDG are based. The Millennium Declaration states in item 19, "*We resolve further..., by the year 2015,... to halve the proportion of people who are unable to reach or to afford safe drinking water*" (UN 2000).

'*Reach*' seems to express a concern with physical access such as ease of access, secure access, collection time, amount of water collected; '*afford*' might indicate a concern of economical access, while '*safe*' has already been discussed before. The Millennium declaration seems only concerned with '*drinking water*' which, if health or wellbeing is a concern, might be too narrow a focus.

The Millennium Development Goals (UN 2001a, 2001b) are the road map for implementing the Millennium Declaration. In regard to water this document stated:

Goal No.7: Ensure environmental sustainability;

Target 10: Halve, by 2015, the proportion of people without sustainable access to safe drinking water;

Indicator 29 [1]: Proportion of people with sustainable access to an improved water source.

The targets under this goal are linked to '*environmental sustainability*' as discussed in the previous chapter. However, drinking water is only a fraction of the fresh water use by humans and by no means the main reason for the depletion of fresh water

[1] After the Johannesburg World Summit on Sustainable Development this became indicator nr. 30!

resources. '*Sustainable*' and '*access*' broadens the scope of the definition compared to words such as '*reach*' and '*afford*' used in the Millennium Declaration, but simultaneously, they are terms that are less clearly defined. The indicator suggested looks at sustainable access to an '*improved*' '*water source*', replacing the terms '*safe*' and '*drinking water*'. This change in terminology by the WHO/UNICEF Joint Monitoring Programme responsible for the monitoring of this target, reflects both the past misrepresentation of what really is measured, and the future uncertainty in judging and defining services as '*safe*' in terms of human health (Hunt 2001).

Questions could be asked whether the indicators suggested in the MDGs are adequate for the monitoring of Target 10 and Goal 7. This discrepancy has been noted by the former Millennium Development Task Force on Water and Sanitation (Lenton 2005). However further reflections such as these falls outside the scope of this thesis. Neither policy '*goals*' nor '*targets*' as described above, or the '*indicators*' which are part of these policies, prove to be a suitable basis to formulate a measurable definition. Additional scope for measurable definitions will be explored by examining at international water rights.

3.1.2 International rights regarding water

At the United Nations Conference in Mar del Plata 1977 it was decided that "*...all people, whatever their stage of development and their social and economical conditions, have the right to have access to drinking water in quantities and of a quality equal to their basic needs*" (WHO/UNICEF 1978). These basic needs were also recognised and endorsed by the WHO/UNICEF International Conference on Primary Health Care in Alma Ata, 1978, which included "*...the provision of adequate supplies of safe drinking water and basic sanitation...*" as one of its essential strategy elements (WHO/UNICEF 1978).

In terms of the right to water, General Comment 15 by the International Covenant on Economic, Social and Cultural Rights (CESCR) is the most explicit UN document regarding rights to water (UN 2002a). The CESCR, one of six UN human rights treaty-monitoring bodies, published General Comment 15, titled "*The right to water*", in the run-up to the World Water Forum in Kyoto. The document provides guidelines on the interpretation of specific aspects of article 12 of the International Covenant on Economic, Social and Cultural Rights (UN 1966) based on various ratified treaties (mainly those which focus on particular vulnerable groups) and regroup them thematically around water issues.

Paragraph 2 of *General Comment 15* affirms that:

> ***"The human right to water entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses."***

Some sceptics of the human right to water seem to have misinterpreted it as a right to free water, but an important factor is economic feasibility (Newborne 2004).

Paragraph 11 of the General Comment states that "*...adequacy should not be interpreted narrowly, by mere reference to volumetric quantities and technologies*".

It further states that in terms of:

- *availability*, water must be sufficient and continuous;
- *quality*, chemically and biologically suitable and aesthetically acceptable;
- *accessibility*;
    - physical, within reach, culturally appropriate and sensitive to gender;
    - economically affordable;
    - non-discriminatory;
    - information, which includes the right to seek, receive and impart information concerning water issues.

While the initial treaties on which this General Comment is based on are legally binding for those states that have ratified them, the General Comments such as number 15 are not. Some countries have national legislation regarding the right to water (see Box 3.1Box). These parameters should be taken into account in surveys in those countries, which can be done by using the additional questions in the *WaSH* survey methodology as suggested in the Chapter 2 (page 43).

South African Constitution (1996), Chapter 2, Bill of Rights, Section 27

1. Everyone has the right to have access to (a) health care services, including reproductive health care; (b) sufficient food and water; and (c) social security, including, if they are unable to support themselves and their dependants, appropriate social assistance

2. The state must take reasonable legislative and other measures, within its available resources, to achieve the progressive realization of each of these rights

Constitution of Gambia (1996) Article 216(4):

The State shall endeavour to facilitate equal access to clean and safe water.

Constitution of Ethiopia (1998) Article 90(1):

Every Ethiopian is entitled, within the limits of the country's resources, to ... clean water.

Constitution of Uganda (1995) Article 14:

The State shall endeavour to fulfil the fundamental rights of all Ugandans to social justice and economic development and shall, in particular, ensure that... all Ugandans enjoy rights and opportunities and access to education, health services, clean and safe water, decent shelter, adequate clothing, food, security and pension and retirements benefits.

Constitution of Zambia (1996) Article 112:

The State shall endeavour to provide clean and safe water.

Tanzania Water Ordinances 1959 16-4

Water Utilisation (Control and Regulation) Act 1974: 15-4

... nothing in any water rights shall be deemed to imply and guarantee that the quantity of water therein refer to is or will be available ...

Source: (van Koppen 2004,p.6) and http://www.righttowater.org.uk/

Box 3.1 : Constitutions of African countries that entrench the right to water

The Tanzanian example is an example in which legislation aimed at controlling the consumption of large water consume but has recently been 'misused' to control small individual consumers for the purpose of taxation (van Koppen 2004).

When national water rights exists they are often more explicit than the international ratified treaties which only implies such rights. Neither national nor international rights are explicit enough to become measurable. An alternative approach to unearth established measurable indicators is to look at established standards and guidelines regarding water supply.

3.1.3 Standards and guidelines regarding water supply

There are various standards and guidelines in regards to water. Many are relating to the supplier while a few relate to the end user. The best known are the WHO water quality guidelines, the International Standard Organisations (ISO) standard 24510 and the SPHERE standards, in which the later focuses on disaster response. The relevance of each of them regarding the *WaSH* survey methodology will be briefly discussed in this section.

WHO "Guidelines for Drinking-Water Quality"

To date the most recent edition of the WHOs Guidelines for Drinking Water states the importance of adequate safe and accessible supply which must be available for all (WHO 2004a). The guidelines' focus, however, is on water quality, be it microbial, chemical, radiological or regarding its acceptability to the user. It defines safe drinking water as "*not representing significant health risks over a lifetime of consumption including sensitivities that may occur between live stages*" (WHO 2004a). WHO acknowledges that "*infants and young children, people who are debilitated or living under unsanitary conditions and the elderly are at greater risk*" but attributes that risk to "*waterborne diseases*". By stating the risk of "*living under unsanitary conditions*" WHO acknowledges indirectly the importance of "*water washed*" disease transmission related to hygiene behaviour and, as such, to water quantity as well as water quality. Safe water (as defined in WHO guidelines) is suitable for all domestic purposes, including personal hygiene (WHO 2004a). By using 'guidelines' rather than a 'standard', WHO recognises that the level of risk reduction in water pollution has to be balanced with the ability of maintaining such a level. This would avoid authorities putting too many resources in water quality when many still lack a minimal quantity of any quality of water.

The judgement of safety, or what is an acceptable level of risk in a particular circumstance, is a matter in which society as a whole has a role to play. The final judgement as to whether the benefits resulting from the adoption of any of the guidelines values as national or local standards justifies the cost is for each country to decide (WHO 2004a). As the guidelines indicate their major focus is on water quality for household use in its broad sense, including monitoring of such quality. This is only a narrow aspect of access to an 'improved' water source.

The International Standardisation Organisation (ISO) "*guidelines for the service to users*" aims to set wider standards and establish "*quality criteria and performance indicators*" for "*service activities relating to drinking water and waste water*" as discussed in the next paragraph.

ISO/24510

The only truly international standard in the making regarding access to water is ISO/24510. The International Organization for Standardization (ISO) responsible for setting this standard is a non-governmental organisation formed through a federation of national standardisation bodies (one per country) from all regions of the world, including developed, developing and transitional economies (ISO 2005a). Through international consensus from the broadest possible base of stakeholders, it distils an international consensus suitable for the standardisation needed (ISO 2005a). Although voluntary, ISO standards are widely respected and accepted by the public and the private sector (ISO 2005a). France, through its national organisation for standardisation (AFNOR), proposed in 2001 establishing an ISO technical committee, which should provide International Standards to help public authorities and other bodies legally responsible for water services, together with their operators to achieve a level of quality that more effectively met the expectations of users and the principles of sustainable development (Redaud 2005). At the time of writing ISO/24510 is in its 'committee draft' stage (ISO/CD24510) and will be submitted to all the ISO members in the spring of 2007 before it is published as a full standard by July 2007. ISO scope explicitly includes "*the definition of users' needs and expectations*" (ISO 2005b) but despite it being designed with the MDG in mind (Redaud 2005) the standard does specifically not cater for "*situations where the point of delivery or point of collection are not the same as the point-of-use or point-of-entry, respectively*" (ISO 2005b). In other words it only covers house delivery of water, mainly piped water delivered by house connections. Additionally it states that the performance indicators in ISO/24510 "*... are not intended for metric benchmarking (among or within countries) ...*" (ISO 2005b).

The narrow scope of the ISO standard and its focus on (piped) water delivery services means that despite its recognition of the MDG it does not cover most of the people currently without access to an 'improved' water source. Other standards such as the SPHERE standards have been set by non-governmental organisations. Although instigated by organisations in emergency relief they are used in development work and discussed below.

The SPHERE standards.

The SPHERE standards were agreed on by a large group of humanitarian non-governmental organisations (NGO) such as OXFAM, CARE, MSF as well as the Red Cross and Red Crescent movement. Initially aimed at increasing the accountability of organisations in emergency relief operation, SPHERE standards are being used outside such crisis situations. After a trial version in 1996, the first edition of 'The SPHERE standards' was published in 2000 with a revised second edition in 2004 (SphereProject 2004). For the Sphere Project "*The minimum standards for water Supply and Sanitation are a practical expression of ... the most basic requirements for sustaining the lives and dignity of those affected by calamity or conflict*" (SphereProject 2000, 2004).

Water supply standard one: Access to Water

All people have safe and equitable access to a sufficient quantity of water for drinking, cooking and personal and domestic hygiene. Public water points are sufficiently close to the household to enable use of the minimum water requirement.

As indicator SPHERE suggests:

- 15 litres/ person/ day;
- Max. distance 500 meters;
- Queuing time at source no more than 15 min.
- It takes no more than 3 min. to fill a 20 l container.
- Water sources and systems are maintained such that appropriate quantities of water are available on a regular basis.

These indicators come with detailed guidance notes (SphereProject 2004,p.64-6).

Water supply standard two: Water quality

Water is palatable, and in sufficient quality to be drunk and used for personal and domestic hygiene without causing significant risk to health.

As indicator SPHERE suggests:

- A sanitary survey indicating a low risk of faecal contamination;
- There are no faecal coliforms at the point of delivery;
- People drink from a protected or treated source in preference to other readily available water sources;
- Steps are taken to minimise post-delivery contamination;
- For piped water supplies, or for all water supplies at times of risk or presence of diarrhoea epidemics, water is treated with a disinfectant so that there is free chlorine residual at the tap of 0.5 mg per litre and turbidity is below 5 NTU[2];
- No negative health effects are detected due to short-term use of water contaminated by chemicals (including carry-over of treatment chemicals) or radiological sources and assessment shows no significant probability if such an effect.

The Sphere Standards minimum standards are clear and suggest definitions as well as indicators to achieve minimum standards. Most definitions, indicators and threshold levels are agreed upon by consensus of the participating organisation (Griekspoor 2001). Although Sphere Standards are concerned with the plight of beneficiaries they tend to focus on service delivery standards mixed with some standards of services received. Moreover some of these organisations are looking for other ways of improving accountability because these organisation have philosophical as well as practical problems with the way in which standards are set and 'enforced' (Do 2005; Hilhorst 2001).

[2] NTU stands for Nephelometric Turbidity Units is an optical property of the water which expresses the percentage of light that is stopped by scattering or absorption of solids suspended in the water.

European Statistical Laboratory's social indicators

The European Statistical Laboratory (ESL), an initiative of the European Union in which EuroStat, the Statistical Office of the European Community, coordinates the improvement of statistical systems in candidate[3] and developing countries.
Its social indicators includes one which ESL defines as:
"*Proportion of the population with access to an adequate amount of safe drinking water in the dwelling or located within a convenient distance from the user's dwelling*" measured in percentages. Although ESL does not provide standards its publications serve as guidelines for statistical offices of nation which have recently joined or aspire to join the European Union as well as statistical offices in developing countries collaborating with the ESL. Under its indicator it defines:

- **reasonable access to water** as: "*...water supply in the house or within 15 meters walking distance*". ESL suggest adapting this definition to local circumstances and proposses in urban areas "*...a distance of not more than 200 meter to a public stand post may be considered reasonable access*". In rural areas it suggests that reasonable access implies that "*...anyone does not have to spend a disproportionate part of the day fetching water for the family's needs*"
- **adequate amount** as "*...the amount of water needed to satisfy metabolic, hygienic, and domestic requirements*". According to ESL this is usually referred to as "*...20 litres of water per person per day*".
- **Safe water** as water that "*...does not contain biological or chemical agents at concentrations levels that are directly detrimental to health*". It considers that safe water includes:
    - Treated surface waters
    - Untreated but uncontaminated water such a:
        - protected boreholes,
        - protected springs, and
        - sanitary wells

[3] Candidate countries to join the European Union

- o Untreated surface waters only if regularly monitored and considered acceptable by a public health officer.

ESL does outline limitations on the indicators. It makes it clear that "*the existence of a water outlet within a reasonable distance*" is often used as a proxy for the availability of safe water. And that the existence of a water outlet is no guarantee in itself that water will always be available or safe, or that people always use such sources.

However, so far the ESL guidelines provide a number of useful elements to help us define access to water, which will be discussed in the next chapter. The next paragraph looks in more detail at water needs such as the "*amount needed to satisfy metabolic, hygienic, and domestic requirements*" as outlined above.

3.1.4 Water needs

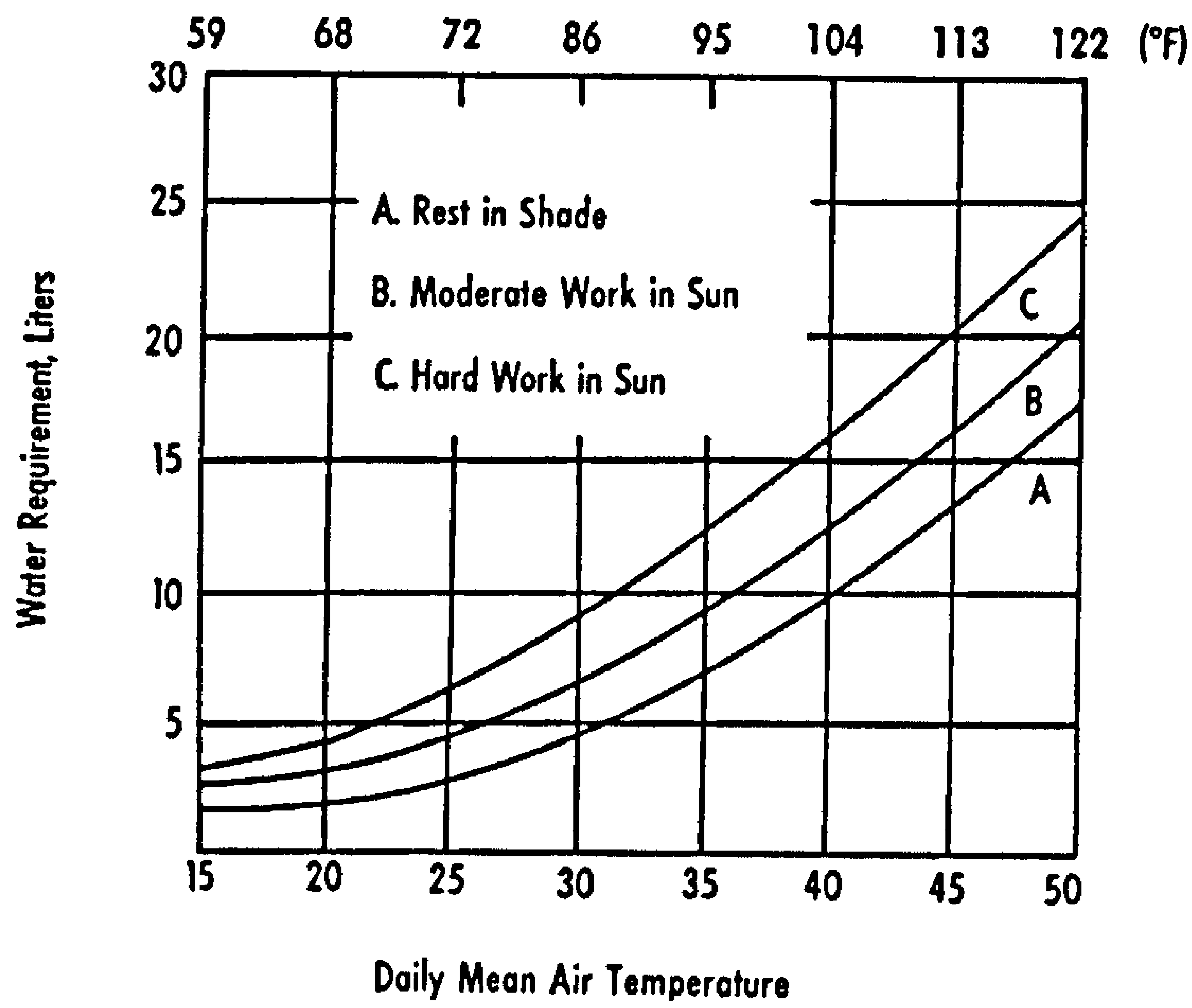
Water is a prerequisite for human life. So when it is stated that people do not have access to water it is clear that 'access' is in this instance not defined as "*the ability to be reached*" (Woodford 2003). All people alive have access to a minimum amount of water necessary for survival. Table 3.1 adapted from Gleick (1996) lists average daily minimum requirements for survival during normal activity and in a temperate climate according to different sources.

Average daily water intake in litres per capita [a]	Reference
1.8 to 3.0	(White 1972)
2.0	(EPA 1976)
2.0	(NAS 1977)
2.2 (female) 2.9 (male)	(Howard 2003)
2.5	(WHO 1971)
2.5[b]	(Roth 1968; Vinograd 1966)
2.5-3	(SphereProject 2004)
5	(Saunders 1976)

[a] Adults during normal activity and temperate climate Adapted from(Gleick 1996)
[b] Fluid requirements measured for early space flight, Recommended min. intake for Apollo astronauts under routine conditions in the command module was 2.9 l/day.

Table 3.1: Average daily water requirements for human survival

These minimum survival needs are based on human hydration under normal conditions in temperate climates acknowledging different needs. Figure 3.1 shows a graph by the US army taking into account different activities and air temperatures.



Source (US Army 1959) in (White 1972)

Figure 3.1: Daily water requirements for three levels of activity

Minimum survival needs seem to be low although variable under different environmental conditions and activities. However there are other activities essential to life which in turn require water. The Sphere Standards set a minimum need of 7.5-15 litres per person per day during times of emergencies. As shown in Table 3.2 this includes water for activities such as hygiene and cooking.

Water use	Amount of water	Remarks
Survival needs: water intake (drinking and food)	2.5-3 litres / day.	Depends on the climate and individual physiology.
Basic hygiene practices	2-6 litres / day.	Depends on social and cultural norms
Basic cooking needs	3-6 litres / day	Depends on food type, social as well as cultural norms
Total basic water need:	7.5-15 litres / day	Adapted from (SphereProject 2004)

Table 3.2: Simplified table of basic survival needs

Howard and Bartram (2003) affirm that "*7.5 litres per capita per day can be calculated as the basic minimum of water required, taking into account the needs of lactating women*". However according to Dr. Bartram, co-ordinator of the Water, Sanitation and Health Programme of WHO "*to date WHO has not provided guidance on the quantity of domestic water that is required to promote good health*" (Howard 2003). This has not stopped other people within the organisation from attempting to do this for WHO. The JMP for example refers in its second report (WHO/UNICEF 1996) to the World Health Organization's definition of access to water as "the availability of at least 20 litres per person per day from a source within one kilometre of the users dwelling" as the standard definition.

In non-emergencies the UK Department for International Development (DFID) states that "*...as a general rule, water supply systems for a minimum level of service should be designed to deliver at least 20 litres per person per day*" (DFID 1998). A range of 20 to 40 litres of freshwater per person per day is according to Peter Gleick (1996), president of the Pacific Institute for Studies in Development, Environment and Security, enough to meet the needs for drinking and hygiene alone. If water for bathing and cooking is included as well, this figure varies between 27 and 200 litres per capita per day. Several different amounts have been proposed as minimum standards(Hinrichsen 1997). Gleick proposes that international organizations and water providers adopt "an overall basic water requirement of 50 liters per person per day" as a minimum standard to meet the four basic needs: drinking, sanitation, bathing, and cooking (Gleick 1996). Falkenmark uses the figure of 100 litres of freshwater per capita per day for personal use as a rough estimate of the amount needed for a minimally acceptable standard of living in developing countries, not including the fresh water required for agriculture and industry (Falkenmark 1992).

It is possible to contrast the rough estimate of water needs with consumption figures from two villages in Mozambique, as outlined in Table 3.3 Table 3.4 illustrates how water for domestic use is extremely scarce in these particular villages on the Mueda Plateau in Northern Mozambique.

Itanda (unsupplied)	Average collection time/journey 5H				
Date (1982)	12/8	13/8	14/8	15/8	Totals
Persons	79	84	83	83	329
Volumes (litres)	34	110	337	562	1349
Average (lcd*)	4.3	1.3	4.1	6.8	4.1
Namaua (supplied)	Each trip took only 10-20 min.				
Date (1982)	6/8	7/8	8/8	9/8	Totals
Persons	39	113	94	92	338
Volumes (litres)	620	1444	948	735	3747
Average (lcd*)	15.9	12.8	10.1	8.0	11.1

* Litres per capita per day (Cairncross 1990)

Table 3.3: Observed average volumes of water used in Itanda and Namaua villages, Mozambique

Residents in the village with the highest consumption use a lower percentage for basic 'survival' needs such as drinking and cooking and more to basic hygiene needs. This results in the use of almost 31 times more water for bathing children in Namaua compared to Itanda. Improving access to water increases water consumption and hygienic behaviour as shown in Table 3.4.

	Itanda (I) (90 pers.-days)		Namaua (N) (95 pers.-days)		factor (N)/(I)
	lcd*	%	lcd*	%	Δlcd*
Drinking	0.21	6	0.36	3	1.7
Cooking	0.67	21	1.93	16	2.9
Washing dishes and food	0.50	15	1.36	11	2.7
Bathing	0.80	25	4.75	39	5.9
Bathing children	0.04	1	1.23	10	30.8
Washing clothes	0.54	17	2.64	21	4.9
Production (animals drinks, etc)	0.48	15	0.03	0.3	0.01
TOTALS	3.24	100	12.30	100	3.8

* Litres per capita per day adapted from (Cairncross 1987)

Table 3.4: Volumes of water used for various activities in Itanda and Namaua, Mozambique

This raises the question, which will be addressed in the next paragraph, about what is more likely to be beneficial to health: increased water quantity, or better water quality. Although the increase of water used for hygiene seems related to the increased availability this pattern can only be indicative. The comparison of two villages in epidemiological studies was one of the methodological flaws highlighted by Blum et al. (1983). Differences in water consumption patterns could be explained by other difference between the villages. The significant difference in the amount water used for production between both village can be an indicator of their dissimilarity (Table 3.4).

Defining 'access' based on a survival amount of water is illogical, undignified and unethical in its implications. After all anybody unable to obtain a minimal amount of water cannot live and therefore will not figure in access to water statistics which only includes survivors. Moreover when using water needs as a determinant of access to water, it requires an insight into the water requirements of different household involved in different activities. Such an approach entails much more information than can be collected in a simple cross sectional-survey.

The impact of water supply on health has been widely accepted (Cairncross 2003). At the same time it is clear that there has been an undue focus on the health benefits of water alone which ignores the many other aspects of how water contributes to wellbeing (Cairncross 2006; Smits 2005). Other aspects relating to access to water will be discussed in the next chapter.

3.2 Defining the sanitation indicator

Unlike water, sanitation is not as well represented in legislation, standards and basic needs. This is rather surprising as the pathogenic load in human excreta is *the* major cause of diarrhoeal diseases (Feachem 1983; Fewtrell 2005; Westaway 2000). Diarrhoeal diseases are according to WHO (2004b) a major cause of mortality and morbidity, which are largely preventable (Cairncross 2006). It is therefore critically important to have effective barriers in place to prevent this major transmission by containing the pathogens at source. Sanitation can reduce diarrhoea morbidity by

36% (Cairncross 2006,p.786,Table 41.7). In this thesis, sanitation is narrowly defined as "*the disposal of human excreta*".

3.2.1 Definition of sanitation targets and goals

As with water, it is worth looking at how sanitation was conceptualised in the past to define "*sustainable access to 'improved' sanitation*" for the *WaSH* survey methodology.

In 1992 the right to '*appropriate sanitation*' was defined by WHO/UNICEF (1992) as '*access to appropriate disposal of sewage*', which indicated that connection to a piped sewage system was at that time seen as the only appropriate way of excreta disposal. UN division of sustainable development defines sustainable development indicators as the "*percentage of the population with adequate sewerage disposal facilities*" (UN 1995b) which ignores any form of on-site sanitation. Their claim that this indicator is "*defined by a group of experts and tested*" seems doubtful.

The first definition by the JMP stated "*sanitary means of excreta disposal*" as "*access to a sanitary facility for human excreta disposal in the dwelling or located within a convenient distance from the user's dwelling*" (WHO/UNICEF 1993). As with water the document states explicitly that the definition of the underlined words has to be done at country level (WHO/UNICEF 1993). This non-standardised approach is in line with other reports which state that "*external imposed definitions simply add an unjustifiable burden to the monitoring process*" (WHO/UNICEF 1996). The same report states that "*...countries in general regard excreta disposal facilities which break the faecal-human transmission route as adequate*" (WHO/UNICEF 1996). The report falls short of illustrating what different countries consider adequate disposal facilities to break this "*faecal-human transmission route*". Vision 21 is the first expression of a clear international goal in sanitation (Table 2.1 page 37). Its second intermediate target is defined as "*Percentage of people who lack adequate sanitation halved*" by 2015 (WSSCC 2000b). However, what can be considered *adequate* sanitation is not clarified in Vision 21. Following the World Summit on Sustainable Development in Johannesburg in 2002 MDG, Target 10 was extended from "*...access to drinking water*" to "*...access to drinking water and basic sanitation*".

The indicator to be used for measuring progress became Indicator 31: "*Proportion of people with sustainable access to improved sanitation*". As with the water indicator it is not clear what is meant exactly with *sustainable, access* and *improved.*

The MDGs definition for sanitation:

Goal 7; Ensure environmental sustainability

Target 10; Halve by 2015 the proportion of people without sustainable access to safe drinking water and sanitation

Indicator 31; Proportion of population with sustainable access to improved sanitation, urban and rural (UNICEF – WHO)

3.2.2 International rights regarding sanitation

As mentioned in Chapter 2, international rights implicitly refer to water and sanitation. In contrast to water there is no explicit international right to sanitation. Despite international agreements there is at least one country that is on the point of recognising this right in its new constitution. After more than two years consultation with ordinary Kenyans, the Kenyan Review Commission responsible for drafting the Kenyan Constitution included in its charter that "*everyone has a right to a reasonable standard of sanitation*" (IRC 2003). The MDG target 10 as agreed in Johannesburg can be seen as the first international step in recognising the right to sanitation.

3.2.3 SPHERE standard

Under the SPHERE standards (SphereProject 2004) excreta disposal standard one: <u>access to and number of, toilets</u>, is defined as:

People having **adequate numbers** of toilets, **sufficiently close** to their dwelling, to allow them **rapid, safe and acceptable access** at all times of the **day and night**.

Some points from the sanitation SPHERE standard one are listed below

- No more than 20 people per individual toilet;
- Less than 50 meters away from dwelling;
- If not private, then segregated, by sex;
- Shared and public toilet are cleaned and maintained in such a way that they are used by all intended users;

- Toilets are used the most hygienic way and children's faeces are disposed of immediately and hygienically.

Excreta disposal standard two: design, construction and use of toilets, is defined as:

Toilets are **sited, designed, constructed** and **maintained** in such a way as to be **comfortable, hygienic** and **safe** to use.

Some points from the sanitation SPHERE standard two are listed below

- Construction of toilet allows use by all: children, elderly, pregnant women, physically and mentally disabled people;
- Suitable situated so they are safe particular for women and girls day and night;
- Sufficiently easy to keep clean so as to invite use and do not present a health hazard;
- They provide a degree of privacy in line with the norms of the users;
- They allow for the disposal of women's sanitary protection, or provide women with the necessary privacy for washing and drying sanitary protection cloths;
- Minimise fly and mosquito breeding;
- Water based systems have enough water supply;
- Pit latrine and soakaways (for most soils) are at least 30 meters from any groundwater source and the bottom of the latrine is at least 1.5 meters above the water table. Drainage or spillage from defecation system must not run towards any surface water source or shallow groundwater source.
- People wash their hands after defecation and before eating and food preparation;
- People are provided with tools and materials for constructing, maintaining and cleaning their own toilets if appropriate.

While Sphere touches on various aspects relating to access to sanitation it does not provide a measurable definition of what constitutes access to sanitation from the perspective of the user.

3.2.4 European Statistical Laboratory

ESL (1996) define basic sanitation in a 'Brief Definition' (*sic.*) as the "*Proportion of population with access to a sanitary facility for human excreta disposal in the dwelling or immediate vicinity*". It goes further in specifying in the same document that "*A sanitary facility is a unit for disposal of human excreta which isolates faeces from contact with people, animals, crops and water sources. Suitable facilities range from simple but protected pit latrines to flush toilets with sewerage. All facilities, to be effective, must be correctly constructed and properly maintained*"

The longer definition touches on various aspects regarding access to sanitation but as with Sphere it does not provide the clear 'universally' accepted indicator desired for the *WaSH* survey methodology. ESL (1996) also warns that "*the availability of facilities does not always translate into their utilization*", an issues covered in the next chapter which will define the indicators more clearly.

3.3 Defining the Hygiene Practice Indicator

Also similar to sanitation, hygiene behaviour or the promotion of an enabling environment for 'improved' hygiene behaviour is not covered in any international rights. Contrary to sanitation, hygiene is not even covered in any international agreement such as the MDG either. Despite that it is still regarded by the UN Millennium Project as an essential part in the water and sanitation sector (Sachs 2004). While provision of 'improved' access to water and sanitation is vital to improve health, it is acknowledged that health gains will only be commensurate with investment in 'improved' hygiene practices (Stanwell-Smith 2003). The only target referring to hygiene is V21's first target described as "*Good hygiene practices universally applied*" by 2025 with an intermediate goal of "*Universal public awareness of hygiene*" by 2015. *Universal public awareness* requires different indicators than those required to measure *application of good hygiene practice*. To avoid different indicators for measuring progress over these two periods, this thesis aims to quantify the *proportion of people applying 'improved' hygiene behaviours.* This puts the measurement of a hygiene target in line with the two previous indicators discussed in this chapter.

3.3.1 Definition of 'improved' hygiene behaviour

It is easy to see that hygiene behaviour is important but more difficult to define what constitutes 'improved' hygiene behaviour. The current dictionary definition of hygiene refers generally to the promotion of health, but the public health definition of hygiene is rooted more specifically in cleanliness of water, food and the environment (Stanwell-Smith 2003). The popular perception of hygiene leans more towards the avoidance of dirt and the killing of germs (Stanwell-Smith 2003).

As with the other indicators the next paragraph examines existing descriptions of 'improved' hygiene behaviour in legislation, hygiene standards and needs to define the *WaSH* hygiene behaviour indicator.

3.3.2 Rights, standards and needs regarding hygiene behaviour

While there have been international accepted targets and goals for water and sanitation there are none for hygiene behaviour. Article 12 of the International Covenant on Economic, Social and Cultural Rights (UN 1966) is the only international law referring to hygiene as discussed in Chapter 2 (Page 41) but refers to "*...all aspects of environmental and industrial hygiene*" rather than personal hygiene. There is also little information about hygiene behaviour needs. The Sphere standards contain information regarding hygiene but relating to *hygiene promotion standards* rather than on standards of behaviour itself (SphereProject 2004). The Sphere Project defines the goals of hygiene promotion as *enabling risky hygiene behaviours to be avoided* but without clearly defining what these risky behaviours entail. This makes hygiene behaviour the less well documented of the three indicators and the biggest challenge to define.

3.4 Summary

This chapter aimed to identify an established consensus in defining access to water, sanitation and hygiene behaviour. It looked into definitions of existing targets, international rights, existing standards, and defined needs for such consensus. The chapter demonstrated that for none of the three indicators, are there obvious, clear and measurable definitions or indicators on which a consensus has been reached.

Where thresholds have to be defined it shows that there is no absolute and scientifically justified level at which to set such an indicator. Therefore, setting the indicator becomes mainly a political decision. What is important for the acceptance of such an indicator is consultation with stakeholders. In addition a worldwide consensus on universal indicators, as discussed in Chapter 2 (page 43), would be difficult as it has to take into account a myriad of situations for which definitions and indicators have to be adequate. This can partially be solved by using different levels of data collection as suggested in the second chapter (page 44) by using core, optional and additional 'questions'.

The next chapter will establish the *WaSH* indicators based the information required to adequately describe the critical aspects regarding coverage for each of the three indicators and propose an indicator for field testing. It will also look at possible ways to validate such indicators.

CHAPTER 4 DEFINING THE *WASH* INDICATORS

4.1 Introduction

As discussed in Chapter 3 no definition for measuring WASH access or practice at the household level is readily available, be it in international legislation or existing standards. This lack of existing definitions and indicators requires creating 'new' ones for the *WaSH* survey methodology. The indicators proposed by the author had to be acceptable for the WSSCC task force on monitoring which scrutinised the proposed indicators at the early stages of their development.

This chapter documents the development of measurable definitions for each of the three indicators to be tested in the field trials. No single question or observation can fit any of these indicators. To design indicators, different questions and observations will have to lead to a value of the indicator. Therefore, not only must one determine the question and observations but also their relationships in a decision model, which leads unambiguously to the indicator.

The data collected are a surrogate for the measure of interest, so it is important that each question and observation clearly states:

- why the question is asked, or the observation is made;
- what will be concluded from the answer;
- what were the assumptions leading to the conclusions;
- any remarks e.g. what to do if the assumptions are proved wrong in a particular survey?

This information is available in Annex B and Annex C.
The combination of survey questions and observations allows triangulation (Almedon 1997; Silverman 2000) to check the validity of outcomes and assumptions.
The major part of this chapter is devoted to determining which aspects are of importance and should be measured in the survey. This is done by looking at various aspects of each indicator and determining how each can be practically measured in a cross-sectional survey by collecting information which determines access or practice. The goal is to describe the critical aspects of the indicator with as few variables as

possible. This minimalist approach is utilised, not only to develop a simple survey methodology, but also to ensure that the methodology "*...concentrates on collecting only that information which each institution has the capacity to manage, interpret and act upon. Otherwise monitoring systems become ineffective as a management tool and may even hinder progress*" (WSSCC 2000). After examining various facets for each indicator this chapter suggests definitions for the indicators and a measurable indicator for field-testing. It also put forwards a method for validating the indicators in field trials.

4.2 Defining access to 'improved' water sources

What constitutes a satisfactory water supply to some costumers is considered by others, even in developing countries, as an inferior service. In Africa access to a hand pump at 500 meters from the household is for many people a luxury, but in urban Latin America , most residents would not consider water supply satisfactory unless they had a house connection (Cairncross 2004). Furthermore, a study in the former Soviet Union not only documented piped water delivery but even distinguished between cold and warm water supply (McKee 2006). The definition in this paragraph aims to provide a 'universal' and comparable definition of minimum standards for measuring purposes. The definition focuses on those who are not receiving these minimum standards or the 'unserved' (Section 2.1.7 page 47) and aims to provide comparison between geographical areas and comparison over time. It does not intend in any way to downgrade existing local standards as these are more likely to suit the local context.

The *WaSH* survey will define access to 'improved' water source as:

- Convenient water supply which allows users to;
- Consume drinking-water with a potentially reduced pathogenic load and
- Obtain enough non-drinking-water for basic hygiene purposes.

Table 4.1: *WaSH* definition for measuring access to water

Convenient in this definition does not only refers to the *ease* of obtaining the water. It also includes the *reliability* of the water supply (i.e. "*can be trusted*" (Woodford 2003)) and *predictability*, (i.e. knowing when water is available).

4.2.1 Aspects determining water access

Before water becomes available at the household level it follows a **chain** of events as shown in Figure 4.1 and Figure 4.2 in which each **link** can constrain the accessibility to water, in terms of quantity and quality, of that particular household. Such a chain can include links such as water source, abstraction, transport, treatment, storage, until it gets to the consumer as shown in Figure 4.1.

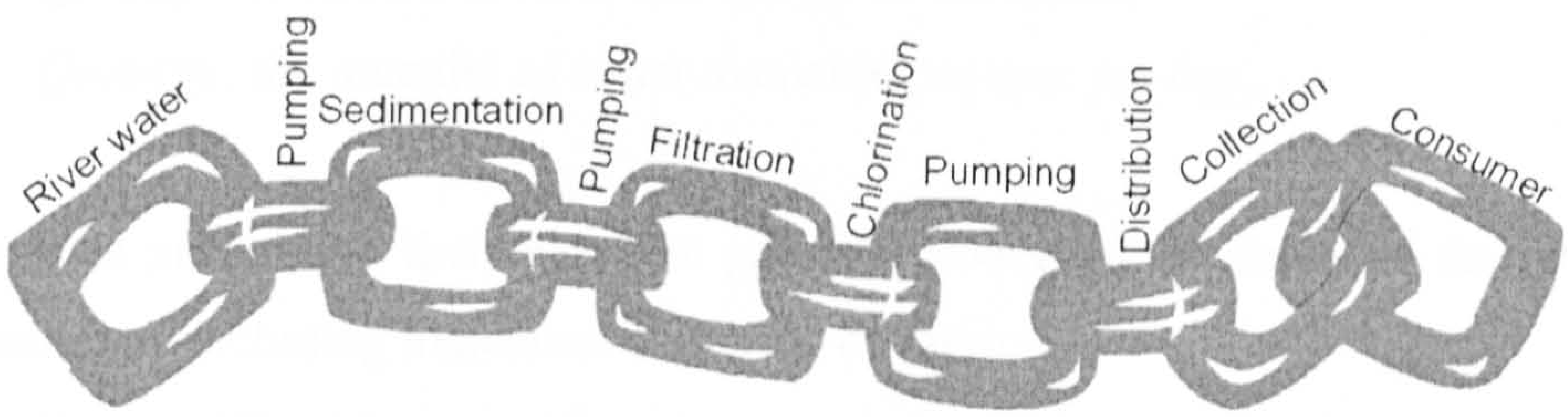


Figure 4.1: One example of water provision chain

These chains can be very long or short as shown in Figure 4.2:

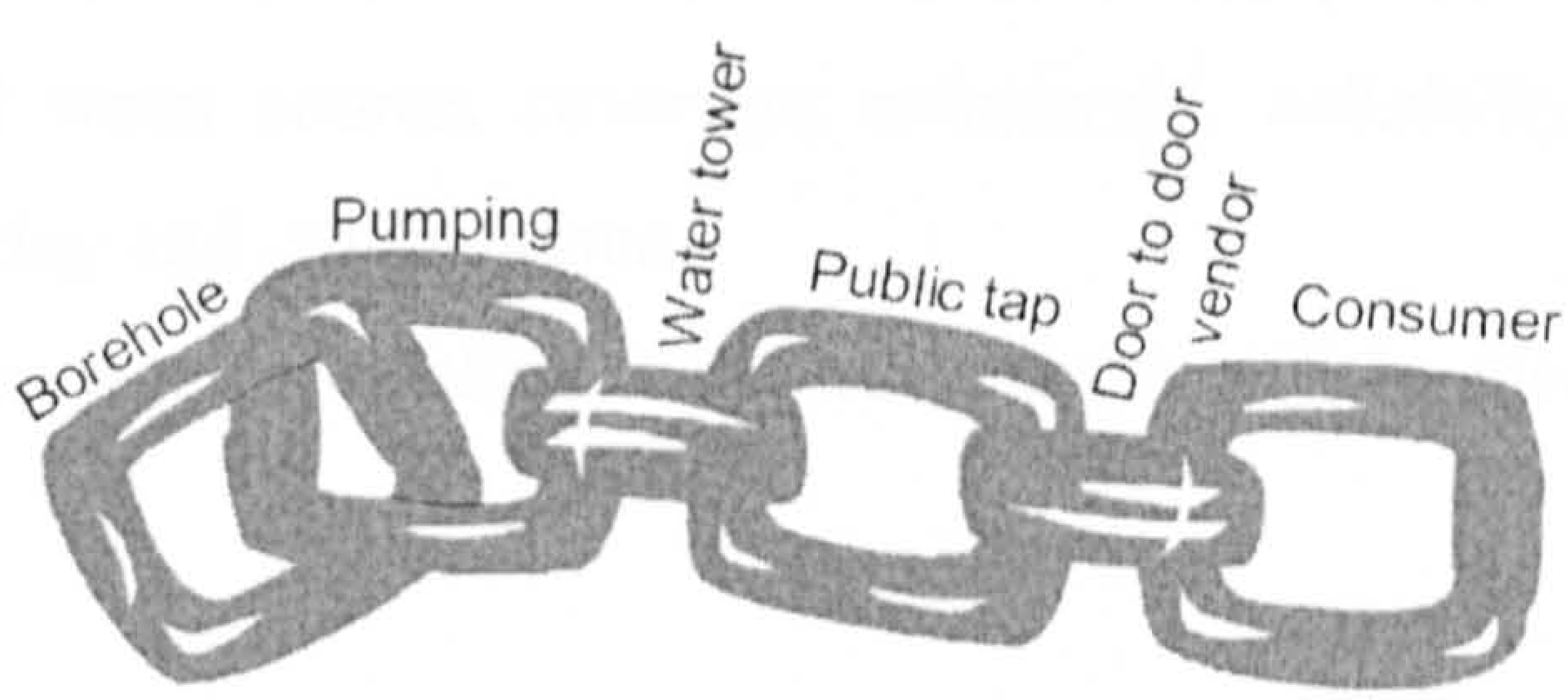


Figure 4.2: Another example of water supply chain

The above examples are not exhaustive in the various steps involved in the water chain; neither do all steps be present in a chain. However, each chain has a water source and a consumer. A similar holistic approach, taking into account all steps in such a chain, is adopted by WHO which uses Water Safety Plans (WSP) as an approach to ensure the safety of drinking-water (WHO 2004a). Such a plan includes all aspects from catchments to consumer and includes a system assessment, effective operation and maintenance as well as management of the system (WHO 2004a). The primary objectives of a WSP in ensuring good drinking-water supply are minimizing contamination of the water source, and reducing or removing contamination during the storage, distribution and handling of drinking-water (WHO 2004a). These objectives are equally applicable to large piped drinking-water supplies, small community supplies and household systems (WHO 2004a).

Lloyd and Helmer (1991) proposed four important parameters for programmes of "*surveillance of drinking-water quality in rural areas*". These are:

1. *Coverage:* the proportion of the population served and
   the proximity of the source to the place of use;
2. *Continuity:* the reliability of supply throughout the day and the year
3. *Quality:* bacterial and chemical quality of the water;
4. *Quantity:* the quantity of water available per user per day.

In the same publication their Peruvian partners broadened the scope of the intended assessment by including indicators of quality of service:

5. *Cost:* tariff paid per month
6. *Sanitary risks:* number of points of risk identified during inspection

House and Reed (1997) determined seven factors of importance in choosing a water source: *type* of water source, *coverage*, *standards*[1], *reliability*, water *quality*, user *charges*, *operating* and *maintenance*.
These and others aspects relating to access to water will be discussed in more detail below.

Type of water source

One of the most important factors determining access and availability is the type of water source used (GoU 2003; House 1997; Lloyd 1991; WaterAid 2001).
There are three main types of water sources, depending on where water is collected as shown in Figure 4.3:

- precipitation such as rain, snow, hail, etc;
- surface waters such as rivers, lakes, ponds, etc;
- ground water such as well, artesian well, spring, etc.

[1] Standard required by local or national legislation

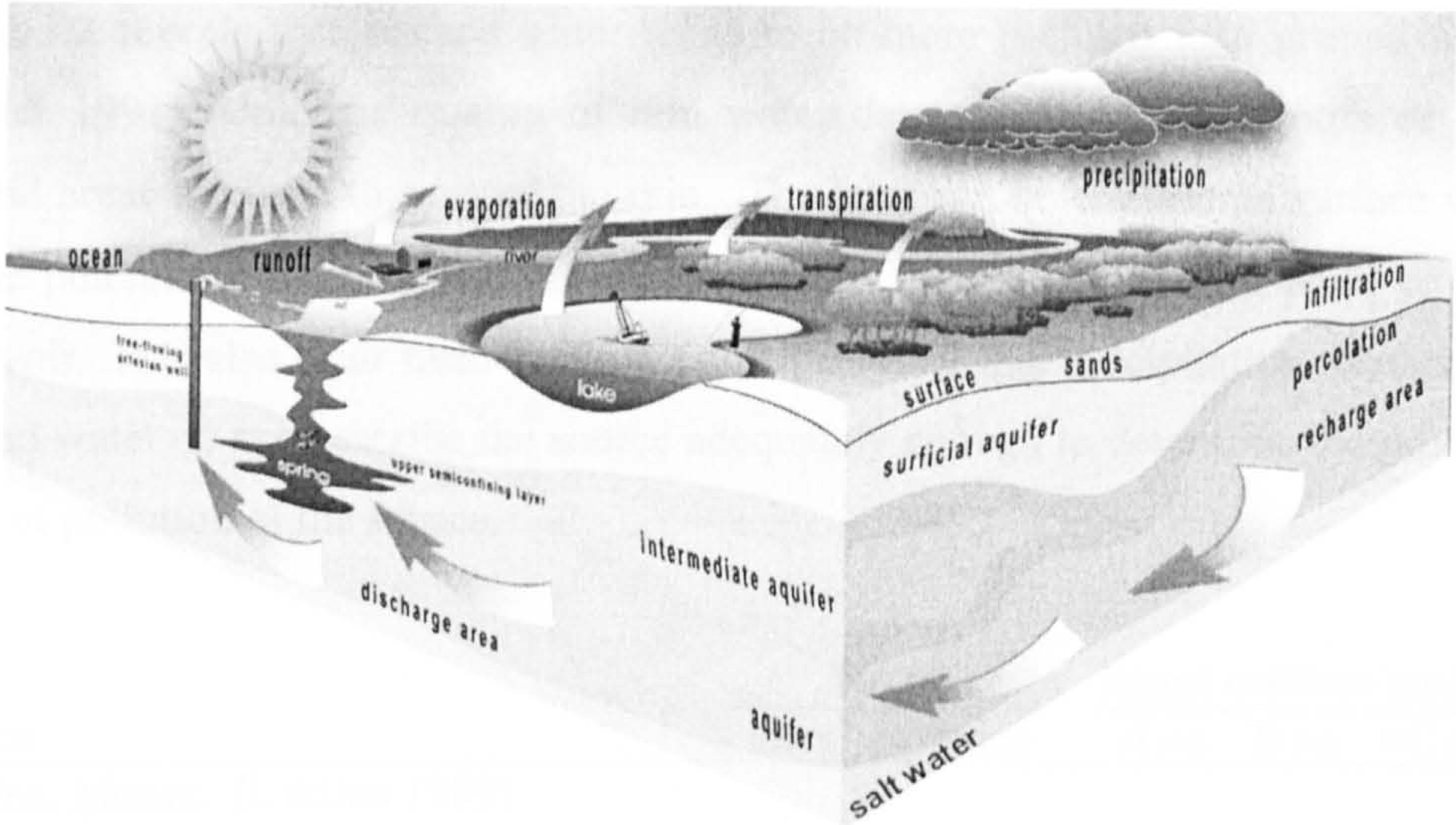


Figure 4.3: Water cycle including precipitation, surface and ground water

Each of these sources will have a different water quality as shown in Table 4.2.

Source	Typical E.coli[1]/100ml	Turbidity[2] (NTU)
Surface water		
• Highland stream	0–10,000	<20
• River	100–100,000+	76–2000+
• Lake, reservoir, Irrigation channel	100–100,000	0–2000+
Ground water		
• Protected spring	<10	<20
• Closed dug well	<10	<20
• Open dug well	10–10,000	0–75
• Borehole	<10	<20
Rain water		
• Ground based	100–100,000+	76–2000+
• Roof based	0–100	<20

[1] Escherichia coli or E-coli is an indicator organism (bacteria) to quantify faecal pollution.
[2] Nephelometric turbidity unit or NTU expresses the turbidity of water the proportion of light stopped by the water.

(Adapted from Davis 2002, p.291)

Table 4.2: Water quality in function of different water sources

Table 1.2 reveals that surface water tends to be more polluted than ground waters (Gorter 1991) while the quality of rain water depends on whether roofs or large ground areas are used to capture the rain. The later can be considered surface water as the potentially polluted run-off water is most often collected in a pond or open reservoir. It is also clear from Table 4.2 and Table 4.3 that precipitation, surface and ground water do not describe the source adequately enough to determine the probable level of pollution of the source.

Source	No of		Faecal coliform grade*		
	sites	samples	A (%)	B (%)	>C (%)
Zambia, Mongu (Utkilen 1989)					
1. Handpumped tubedwell (>10m deep)	32	40	100	0	0
2. Standpipe from borehole	34	35	100	0	0
3. Handpumped dug well (concrete rings as lining)	7	14	93	0	7
4. Dug well (windlass)	98	266	78	14	8
5. Traditional source (unprotected)	108	148	42	20	38
6. Spring	4	9	89	11	0
7. Stream	6	14	28	29	43
8. Unprotected shallow well	14	17	53	41	6
Malawi (Lewis 1984, 1989)					
1. Hand pumped tube well and boreholes		300	60	34	6
2. Hand pumped dug wells		na	81	14	5
3. Unprotected dug wells		60	8	2	90
Java, Gunung Kidul (Lloyd 1991)					
1. Handpumped tubewell					
a. Deep (>10m)		44	59	25	16
b. Shallow(≤10m)		100	72	14	14
2. Handpumped 'protected' dug well		97	20	32	48
3. Open dug well with parapet		55	5	58	37
4. Rainwater tanks		32	6	31	63

*Faecal coliform (E-coli) grading: A= 0/100 ml; B= 1-10/100 ml; C= >10/100 ml

(Corrected from Lloyd 1991,p.131)

Table 4.3: Faecal contamination of water sources by type of water source

The level of protection against run-off water and other sources of pollution will also have an impact on the water quality as discussed later. This is reflected in Feachem's classification of water sources used in Lesotho as shown in Table 4.4 (Feachem 1978a).

	Types of water sources	
S1	Unprotected spring	'unimproved'
S2	Waterhole	"
S3	Small dam	"
S4	Stream	"
S5	Protected spring	'improved'
S6	Protected spring with storage and reticulation	"
S7	Borehole with wind-pump, storage and reticulation	"
S8	Borehole with diesel engine, storage and reticulation	"
S9	Borehole with hand pump	"
S10	Roof catchment	"

(Feachem 1978a,p.95)

Table 4.4: Classification of (un)improved sources in Lesotho

Feachem (1978b, p114-5) noted that although this classification is accurate most of the time, unprotected springs in the highlands of Lesotho proved to be of better quality and significantly cleaner than the lowland protected springs. Occasional exceptions can be made to the rough classification shown in Table 4.4 but not to the extent that it undermines the proposed classification.

Since the publication of the JMP Global Water Supply and Sanitation Assessment 2000 report (GA2000) (WHO/UNICEF 2000), a similar classification of water sources is used by the JMP, based on their likelihood of being contaminated Table 4.5.

Most health benefits are obtained by hygiene practices like washing and to a lesser extent by 'improved' water quality (Billig 1999; Cairncross 1995) as explained later in this chapter on page 118.

'improved' water supply	'unimproved' water supply
Household connection	Unprotected well
Public stand pipe	Unprotected spring
Borehole	Vendor-provided water
Protected dug well	Bottled water*
Protected spring	Tanker truck provided water
Rainwater collection	

* Bottled water has recently, after discussions in the JMP Technical Advisory Group (TAG), been classified as 'improved' if an alternative source of water was available.

Table 4.5: JMP classification of 'improved' and 'unimproved' access to drinking-water source.

The GA2000 assumes that bottled water, which comes generally at a high cost, will not provide the required quantities for 'improved' hygiene practices. The assumption in the analysis is that in such cases, bottled water is the only source of water. In the 1996 DHS[2] data set for the Dominican Republic for example, 18% (n=8830) of the households stated that they used bottled water as their drinking-water source. Analysis for this research showed that of the households using bottled water, 93% (n=1599) had an indoor or outdoor piped connection. This illustrates that assumptions of one water source have to be carefully checked and access to non-drinking-water assessed to make an accurate appraisal of domestic water provision.

As a result of these analyses by the author of this thesis led the JMP to review their classification for bottled water and reclassify it as 'improved' if another 'improved' water source is used by the house (WHO/UNICEF 2005, p.6).

Water provided by vendors and tanker trucks are also classified as non-improved water sources by the JMP (Table 4.5). Apart of concerns of increased contamination during transport (Clasen 2003; Whittington 1989), water provided by itinerant water vendors is generally much more expensive than the alternatives (Cairncross 1992b; van Zyl 2000; Zaroff 1984). Water cost is discussed in greater detail below.

The quality and quantity of water required will differ between drinking- and non-drinking water. Drinking-water requires access to a water source of good water quality of which relatively low quantities are needed, while for non-drinking, quantity

[2] Demographic Health Survey (DHS III) by ORC Macro[SM] for U.S.A.I.D at http://www.measuredhs.com/.

and convenience are more important than quality. Water quantity and quality will also be discussed in more detail later in this chapter. However, only if both conditions (access to drinking- and non-drinking-water) are satisfied, will the *WaSH* access to water criteria (Table 4.1 on page 90) be fulfilled.

For this reason the *WaSH* indicator for access to water will be split into different criteria: drinking and for non-drinking-water, which both have to be fulfilled. However, the structure of the questionnaire will need to take into consideration those cases when water used for cooking, drinking and hygiene comes from the same water source.

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
21	What is the main source of drinking-water for members of your household ?[1]	PIPED WATER	
		PIPED INTO DWELLING 11	→ 23
		PIPED INTO YARD/PLOT 12	→ 23
		PUBLIC TAP 13	
		WATER FROM OPEN WELL	
		OPEN WELL IN DWELLING 21	→ 23
		OPEN WELL IN YARD/PLOT 22	→ 23
		OPEN PUBLIC WELL 23	
		WATER FROM COVERED WELL OR BOREHOLE	
		PROTECTED WELL IN DWELLING .. 31	
		PROTECTED WELL IN YARD/PLOT. 32	→ 23
		PROTECTED PUBLIC WELL 33	
		SURFACE WATER	→ 23
		SPRING 41	
		RIVER/STREAM 42	
		POND/LAKE 43	
		DAM 44	
		RAINWATER 51	
		TANKER TRUCK 61	
		BOTTLED WATER 71	→ 23
		OTHER ______________________ 96 (SPECIFY)	→ 23

[1] Coding categories to be developed locally and revised based on the pre-test; however, the broad categories must be maintained.

Table 4.6: Example of DHS question and answers on the type of drinking-water source used.

The question used to obtain the information for drinking-water in the DHS survey is "*What is the main source of drinking-water for members of your household*" (ORC Macro 1995, 2001; UNICEF 1999). The answers in the DHS survey contain not only information on the *source type* (spring, well, river) but also on the *delivery* (piped, vendor provided) the *state of the source* (protected and un-protected) and the *place of collection* (in dwelling, in yard/plot) and the type of access (public, private) (Table 4.6).

During the first meeting of the WSSCC monitoring task force on 18 June 2002 some participants insisted that *WaSH* questions should be identical with the JMP[3] question as shown in Table 4.6 to allow for comparable data. This led to difficulties and confusion as it was realised that none of the surveys used for compiling the actual JMP data had been based on identical questions (WHO/UNICEF 2004a) at the time.

Initially the *WaSH* survey used the DHS questions and response categories as requested. A suggestion to replace 'main' by 'last time water was collected' was not accepted by the WSSCC monitoring task force as the JMP was interested in 'the main' source and not the last source used. The problem in asking for 'the main' source is that the survey relies on the judgement of the interviewee to interpret what is meant by 'main' which might be different from the JMP[4]. Because the interviewee makes this judgement, it becomes difficult to validate the given answer. When piloting and using the questions in surveys some small changes (see Chapter 7) were incorporated to ensure that the outcome was compatible with the JMP categories in Table 4.5 rather than standardising the questions as done by the JMP. Another point raised in the same meeting was that if data was collected on multiple sources the questions had to be identical for all sources. For the *WaSH* indicators, this stipulation, which went unopposed and was reluctantly accepted by the author, resulted in the collection of redundant information as shown later. But the use of identical questions for all water sources proved to be less confusing for the interviewers compared to different questions for different sources. It also improved the flow of the interview (see Chapter 7). While the extra data was redundant in determining *WaSH* indicator, it is useful for further analysis other than the *WaSH* indicators, which survey organisations are encouraged to do by the methodology.

Categories such as tap water or vendor water give no information about the initial water source. Whittington (1989) showed that vendors sometimes sell water from polluted sources or polluted containers. This is also in line with Clasen's (2003) findings that transport and storage of water from the point of collection contributes significantly to water quality deterioration. While the questions could be better structured to ask such details during the household survey, it is doubtful that users of

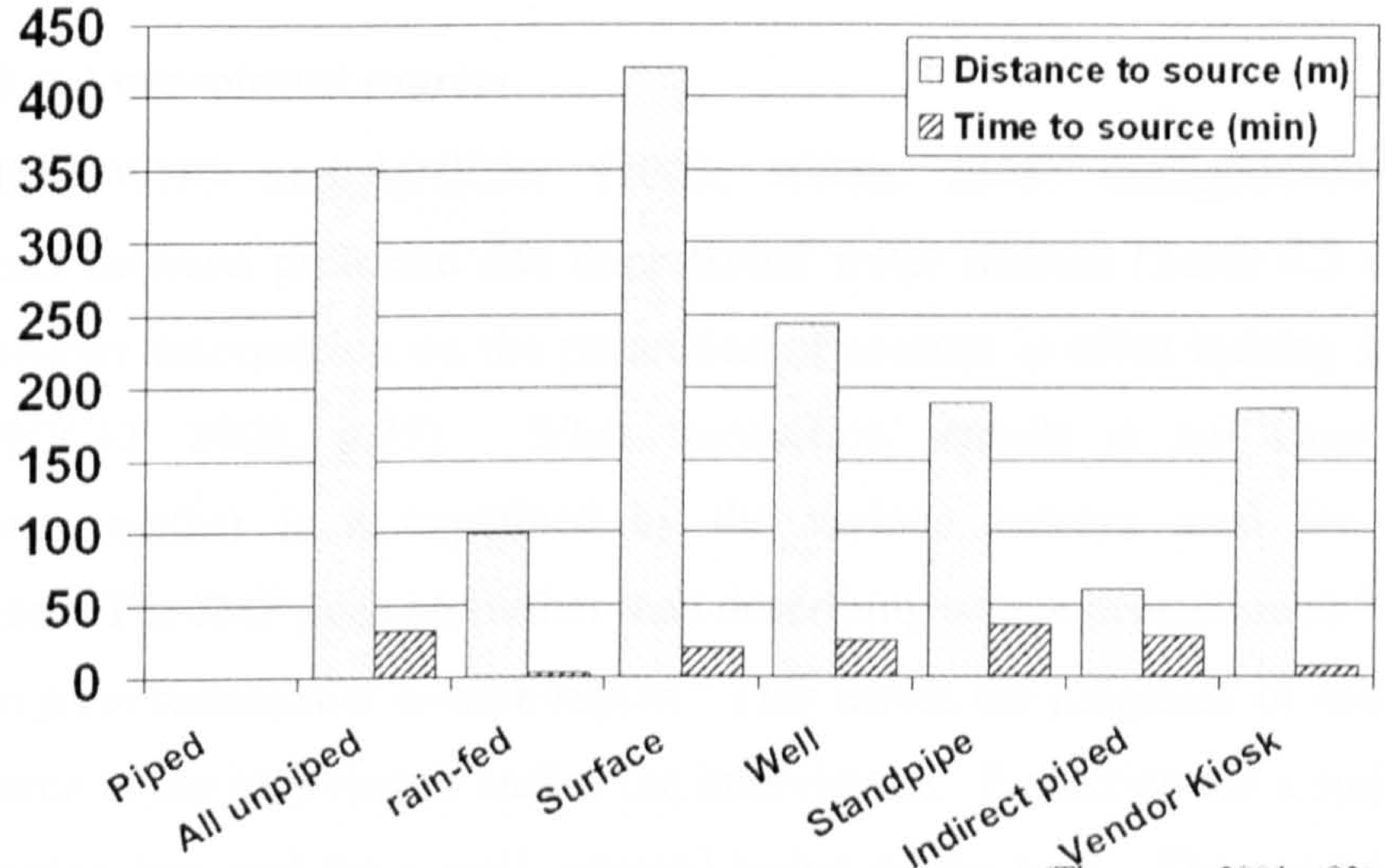
[3] Which means identical to DHS and MICS questions as well as other surveys used by the JMP.

[4] Neither DHS, MICS nor the JMP are clear in what is meant by main source. It was assumed in this thesis that they referred to the source which was most often used by the household throughout the year.

taps, bottled and vendor water know from where their water originates. After all few people, even in high income countries, wonder where their bottled or tap water comes from.

And because questions are asked at household level this means that when collecting data on water sources the required detail of information might not always be available.

Feachem (1978a) remarked that in Lesotho, for 'improved' water sources as defined in Table 4.4, the collection time was significantly less than for 'non-improved' sources. In *Drawers of Water II* by Thompson (2002) a similar pattern seemed to emerge (Graph 4.1).



(Thompson 2001,p.93)

Graph 4.1: Distance and time of water collection per type of water source

Looking at the DHS data the author could not generalise this trend. The Ghana 2003 and Dominican Republic 1993 data sets show that improved water sources required less collection time as postulated by Feachem (1978) while Burkina Faso 2004 shows a reversed correlation and Egypt 2003 demonstrates little difference in collection times between improved and non-improved sources. Graph 4.1 reveals that while the distance for surface water are high the collection times are low compared to standpipes where the distance is half that of surface water but the collection time twice as long mainly due to queuing at the tap. Water collection times as an aspect of access will be discussed in more detail later in this chapter.

Thompson (2002) notes that over a period of 30 years there was a shift in East Africa from relying on one primary source to reliance on multiple sources. The main reasons for this include that primary sources of water became increasingly less reliable while there is an increase in availability of other sources (Thompson 2002). The type of water source as used by the JMP contributes usefully towards a *WaSH* water indicator and will be included in the survey methodology. Drinking water is not the only water of interest and information on water for hygiene purposes will also be collected, acknowledging that households might use multiple water sources. The question as used by the JMP will be used as requested by the WSSCC monitoring task group but additional factors will be looked at, such as a clearer definition for protected and unprotected sources.

Protected and unprotected sources.

Since 2000 WHO and UNICEF (2000; 2004b; 2005) distinguished in their assessments between protected and unprotected water sources (Table 4.5 and Table 4.6). However information on the protection of sources is often lacking in surveys (WHO/UNICEF 2000, p.79). What 'protection' entails is not clear in JMP assessments, neither is it explained by the various surveys used for the JMP assessments. The JMP goes no further than describing source protection as "*adequate protection from subsequent contamination*" This leaves the judgment of such aspects of the source to the interviewer and/or the interviewee. Protection for a spring could mean a spring box and for a well, internal lining of the well. The most important source of pollution is likely to be run-off water. Run-off in developing countries usually contain a degree of faecal contamination (Heller 1999; Parkinson 2003; Prado 2003) which prompted WaterAid in Tanzania to define 'protected' as "*... enclosing the source to prevent contamination by run-off water*" (Marshall 2002). For a shallow well this can be done with a parapet and dedicated water drawing equipment such as a bucket on a rope or a pump (Gorter 1991). At the household level it might be difficult to assess whether a source is properly protected as it requires a lot of technological understanding and judgement on the behalf of the interviewee and interviewer. Moreover various types of protections and their effectiveness are not always easy to judge (Lloyd 1991). To solve such difficulties, Lloyd and Helmer (1991) developed picture check lists for each possible source in which inspectors were requested to circle problems identified when assessing source protection as shown by two examples of such illustrations in Figure 4.4. For cross-section household surveys, this would require visiting each household's water source. With collection times often over 30 minutes this would increase the contact time of the interviewer with the interviewee, particularly if the same information has to be collected for multiple sources. An ideal solution is to collect unambiguous data on the water source at the household.

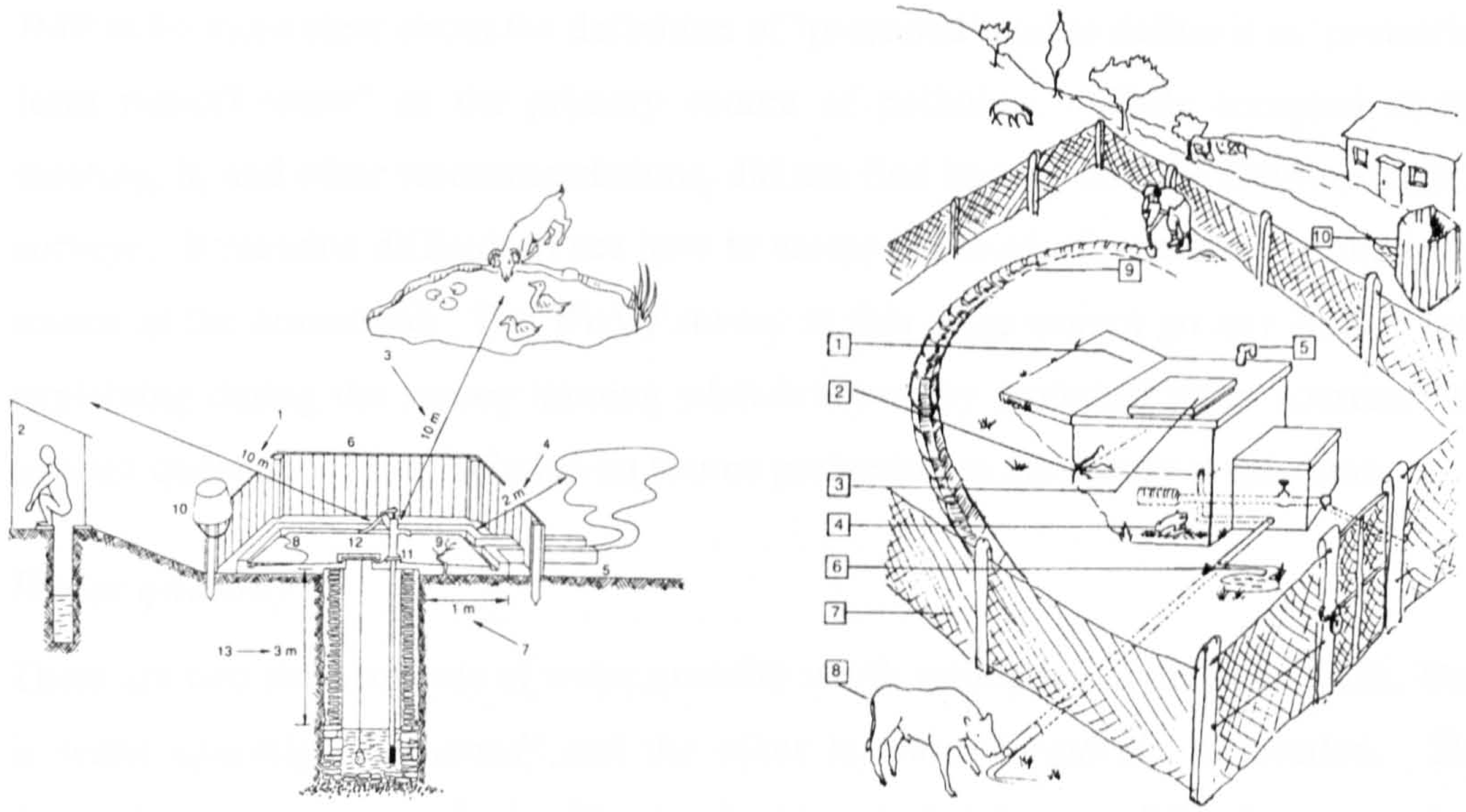


Figure 4.4: Examples of factors relating to water source protection (Lloyd 1991,p.70&76)

Water source protection is mainly relevant to groundwater sources, as the 'hole' used for abstraction is at the same time the principal source of contamination. Initial discussion papers developing the *WaSH* indicators (Bostoen 2002b) suggest that abstraction method such as a pump or dedicated buckets for abstracting the water could be a useful proxy for the level of protection of the source. This assumes that water sources, with for example a hand pump, are less at risk of contamination because they are more likely to be protected from run-off water by a slab or parapet compared to a well, where users draw water with their own non-dedicated buckets or water-bags. However, this is not documented in any literature and in a discussion with participants in the WSSCC monitoring taskforce meeting on 18 June 2002 it was considered too stringent as a criterion. Moreover, UNICEF and WHO were concerned that wells should have a top cover to protect them from psittacosis (transmitted by parrots and budgerigars) and ornithosis (primary transmitted by pigeons). The risk of these however is negligible compared to the risk of run-off water and this requirement was not upheld.

The presence of a stone or concrete structure was another suggestion made by the author to the WSSCC monitoring taskforce but this was not supported. On 11 March 2004 there was one of three *ad hoc*[5] meetings in New York of the JMP 'taskforce on harmonisation of household questionnaires'. In this meeting the author convinced the JMP to be more clear about the definition of 'protected' and to define it as 'protection form run-off water' as the primary source of pollution. While accepted at this meeting, it, and other recommendations, did not find its way into the DHS and MICS surveys. It remains difficult to see how to assess the level of protection of the water source at the household. The *WaSH* survey at this stage cannot go any further than explaining during the survey training what is meant by protected water sources. No explicit question will be included on source protection in the survey at this time.

Water quantity

There are two main aspects of water quantity worth estimating at the household. One is water quantity *'consumed'* and the other is water *'required'* or needed. The discussion on water needs in Chapter 3 showed that it was difficult to set clear minima at which basic needs are met (Table 4.7). The chapter also demonstrated that low quantities of water will have an impact on personal hygiene and consequently on health.

	Minimum quantity of water per person per day in litres				
	15-20	20	20-30	30-50	>50
Number of countries	1	19	5	10	3

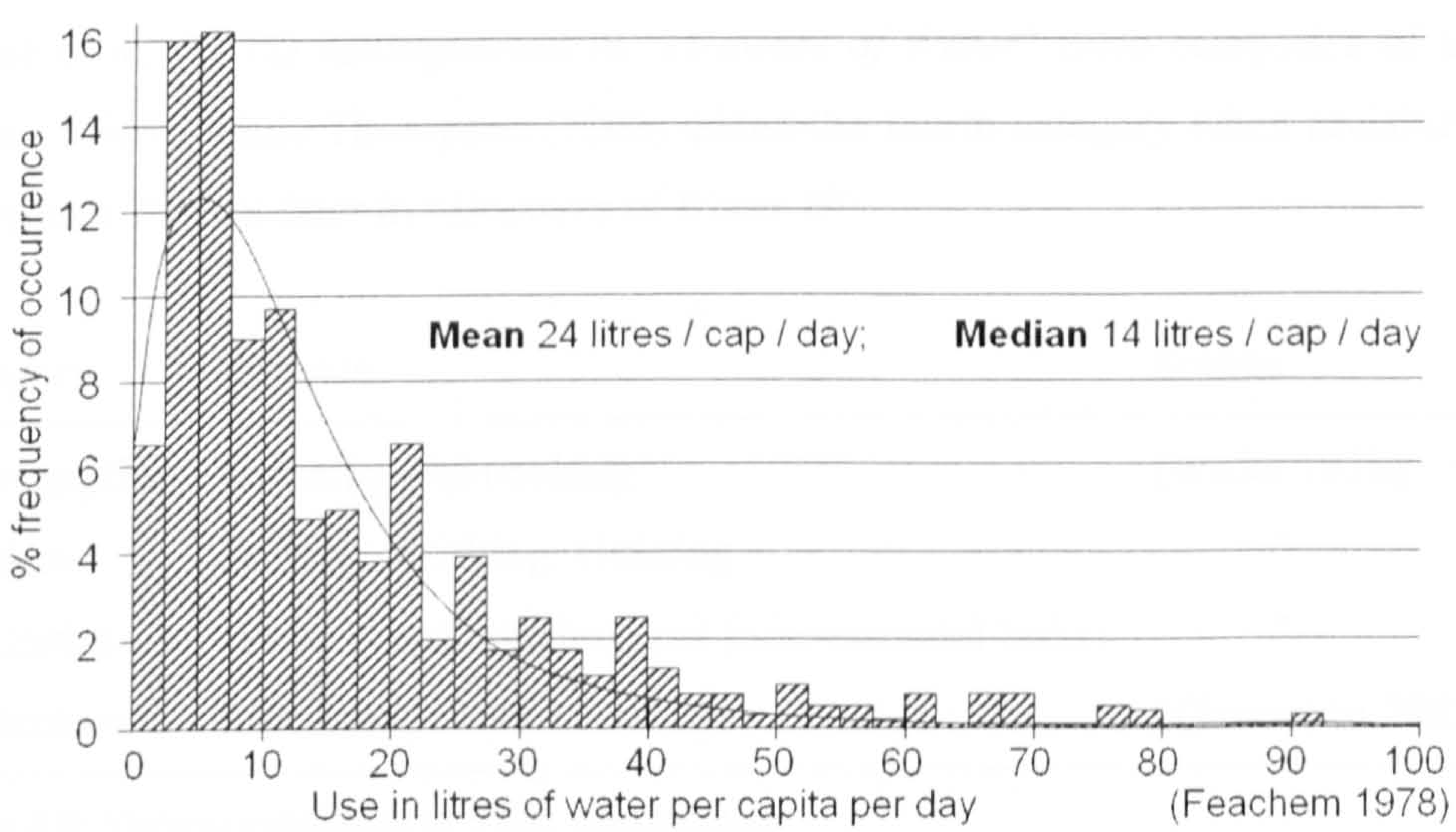
(WHO/UNICEF 1996)

Table 4.7: Minimum of water/cap/day considered access by countries in the world

There are some problems with the choice of water consumption as an indicator. White et al. (1972, 147) showed that the amount of water used, education and ethnic group are all related. Higher social class and being better-off might contribute to this difference but in the same graph White et al. revealed that Africans use less water on

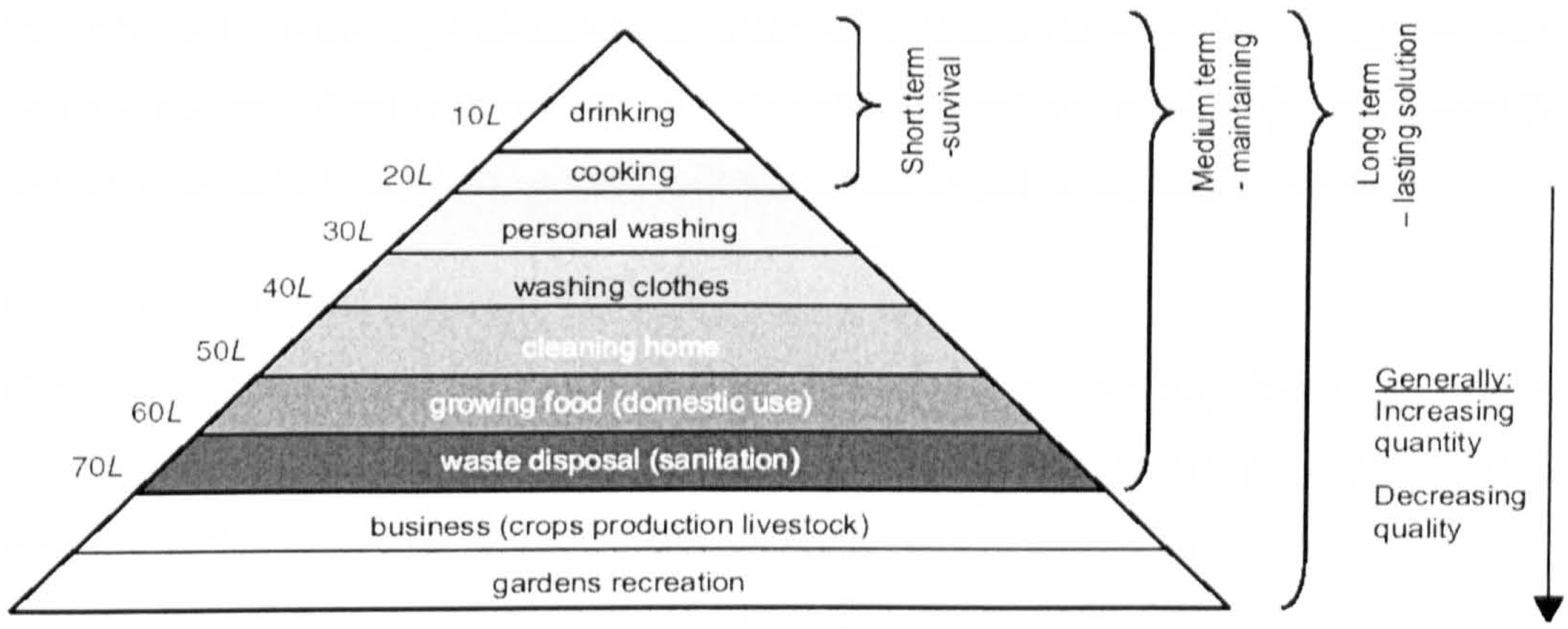
[5] They were referred to as *ad hoc* as they were not linked to any of the JMP or JMP TAG meetings.

average compared to Asians, which in turn use less than Europeans living in the same area. In addition most of the water used at the household level is for non-drinking purposes such as washing (Figure 4.5). Therefore, water consumption appears to be more an indicator for hygiene behaviour than for access. Measuring it at the household assumes that all the water used is taken to the household. But in many cases, people will wash themselves, their clothes or cooking utensils close to the water source. Even collecting larger amounts of water does not imply that it will be used for hygiene purposes. In practical terms it is difficult to measure the consumption, and moreover it has to be measured in relation to the assumed need. A study in Lesotho of 703 households in four villages, resulting in 1334 household days of observation, showed that the amount of water collected per day is extremely skewed (Feachem 1978a). Feachem explained that a typical household on a typical day uses around 6.5 litres for routine domestic tasks such as cooking, drinking, washing. From time to time a household will draw much larger volumes of water (up to 100 litres/capita/day) for non-routine activities such as brewing, plastering, washing clothes and gardening water (Feachem 1978a). It is these high values which account for the high mean values and which makes observation of few households for a few days very misleading (Feachem 1978a). These variations depend on the day the data is collected and could make the data unsuitable for a cross sectional survey when each household is only visited once (Feachem 1978a).



Graph 4.2: Frequency of various amount of water per day collected in Lesotho

If water quantity is used as a proxy for access, it would be better to know if people can take as much water as they want and if they have no limitations in increasing the amount of water they collect if required. To assess whether people use as much water as they want, within the constraints they face, involves posing hypothetical questions which households may find difficult to answer.



(Inspired by Abraham Maslow's (1908-1970) hierarchy of needs by Reed 2005)

Figure 4.5: Hierarchy of water needs

Water usage as discussed next could be a better indicator than the amount of water quantity needed or collected as discussed below.

Water use

White et al. (1972) distinguished in "*Drawers of Water*" three categories of use as shown below, while Thompson (2002) added the fourth category when revisiting the study area 30 year later in "*Drawers of Water II*":

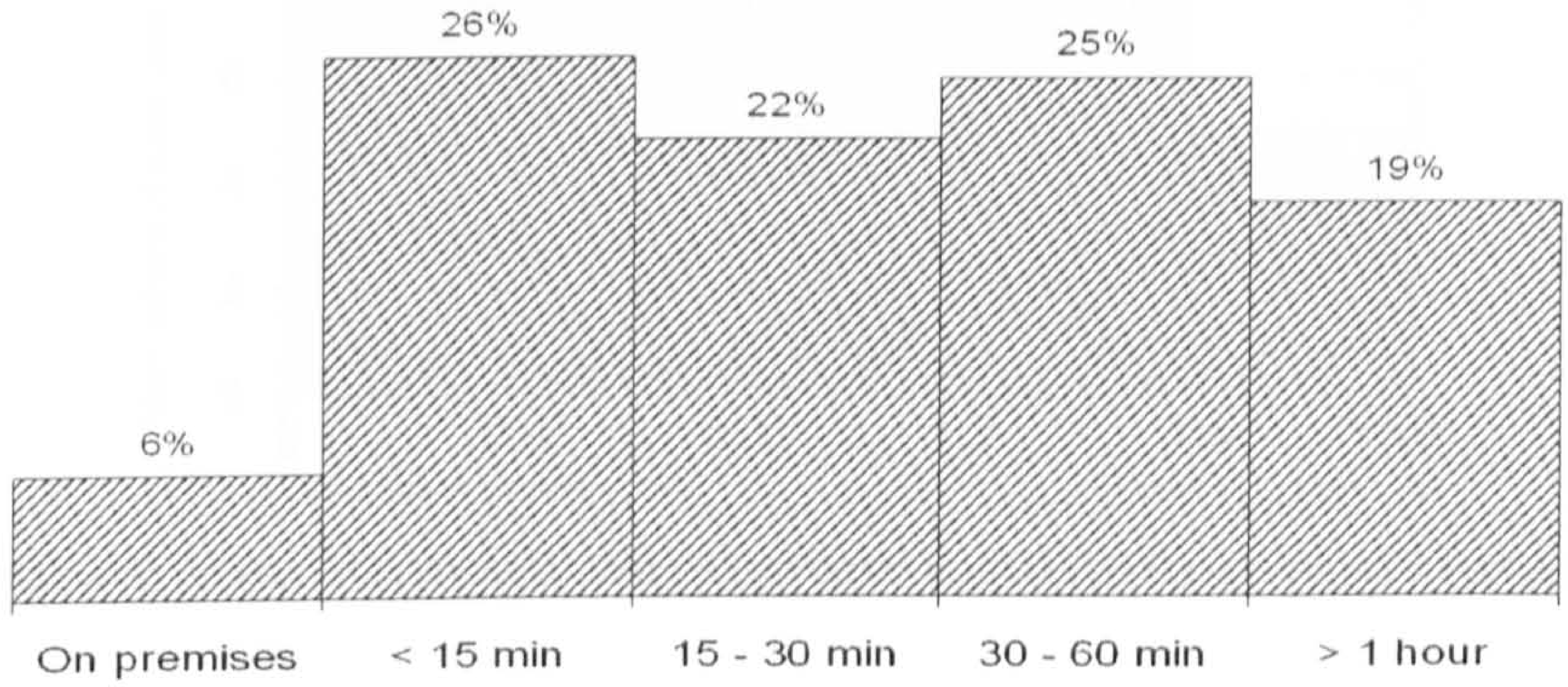
Category	Purpose	Source
Consumption	Drinking and cooking	(White 1972)
Hygiene	Bathing, washing, cleaning	"
Amenities	Water plants, washing car (non-essential tasks)	"
Productive	Livestock, crops, brewing	(Thompson 2002)

Table 4.8: Various categories of water consumption

One of the signs which indicate that people have sufficient quantities of water is the use of water for amenities. However identifying water use for amenities as a reliable indicator that enough water is obtained by the household, proves difficult. As a result it makes this aspect not worth considering. Other aspects such as water collection time, cost of water, and distance to source which are discussed later seem to be better proxies to the amount of water collected. These proxies are easier to collect and for this reason it seems superfluous to measure or estimate directly the amount of water collected or to collect information on water use. Therefore, information on quantities of water collected, required or used will not be collected in the *WaSH* survey.

Distance of the water source

If health was described as it once was by a group of women in Rajastan, as " *being able to finish a day without being exhausted* " (Cairncross 1987) time (and efforts) saved in collecting water would be considered an improvement in health.



Source: Unicef, based on MICS data for 23 countries; analysis by Greg Keast in (Cairncross 2004)

Graph 4.3: Water collection journey times in rural sub-Saharan Africa, 2002

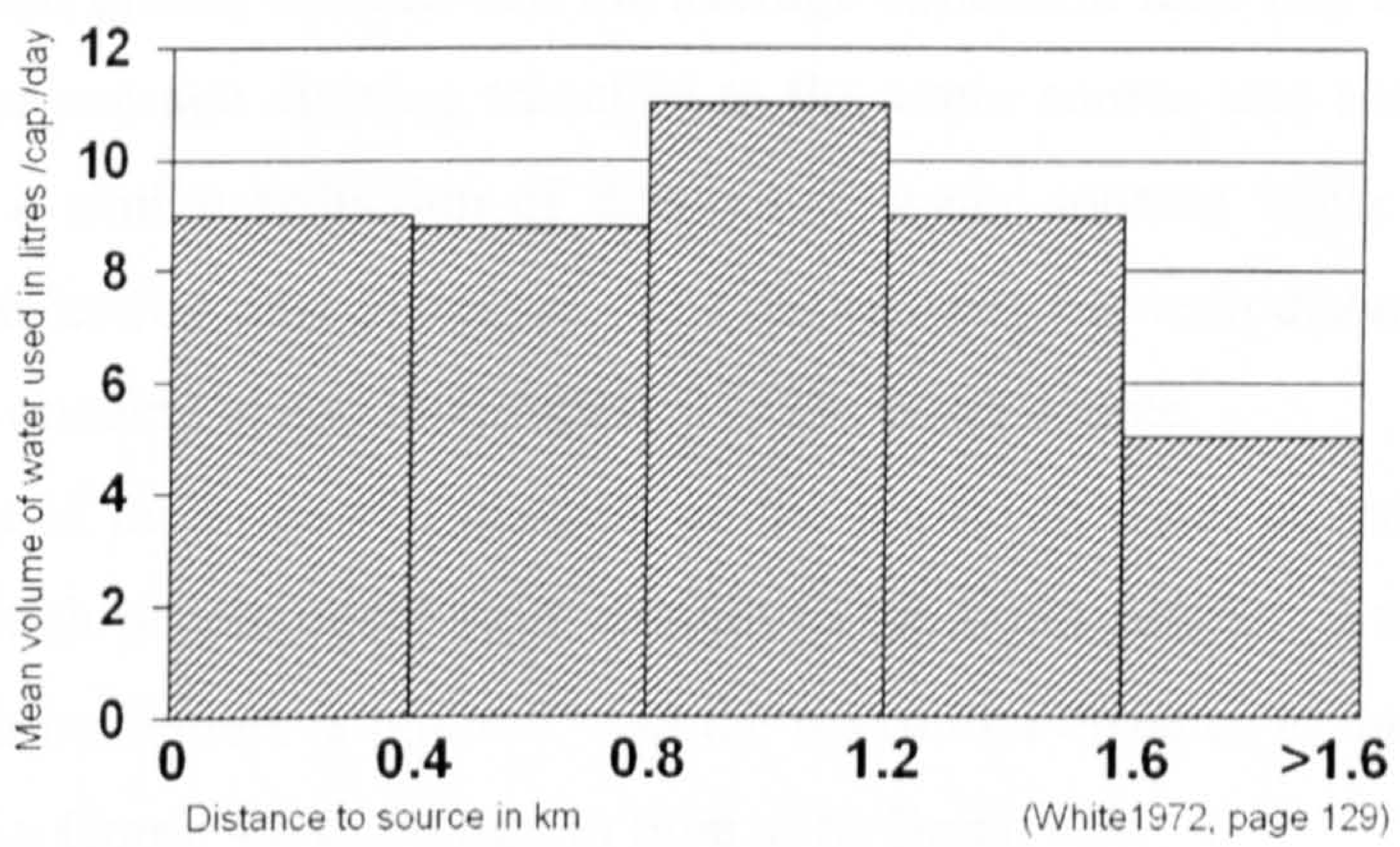
Distance plays an important role in the choice of a water source (Briscoe 1985; Feachem 1978a). When looking at various national definitions of access, the JMP noted that different measures were used to define the cut-off point regarding access (Table 4.9). For example, as the table shows some countries often measured access differently for urban and rural areas. In a study in Eastern Africa, White et al. (1972) found no linear relationship between the amount of water collected per capita per day by the household and the distance to the source in un-piped rural areas.

Access defined as: "*Water source at a distance of less than...*"	.... meters						... min.			Total # of Countries
	50	**100**	**250**	**500**	**1000**	**2000**	**5**	**15**	**30**	
Urban	20	6	3	8	1	0	1	0	1	40
Rural	10	1	6	17	4	4	0	1	1	44

(WHO/UNICEF 1996,p.13)

Table 4.9: Number of countries defining access by distance in meters or minutes

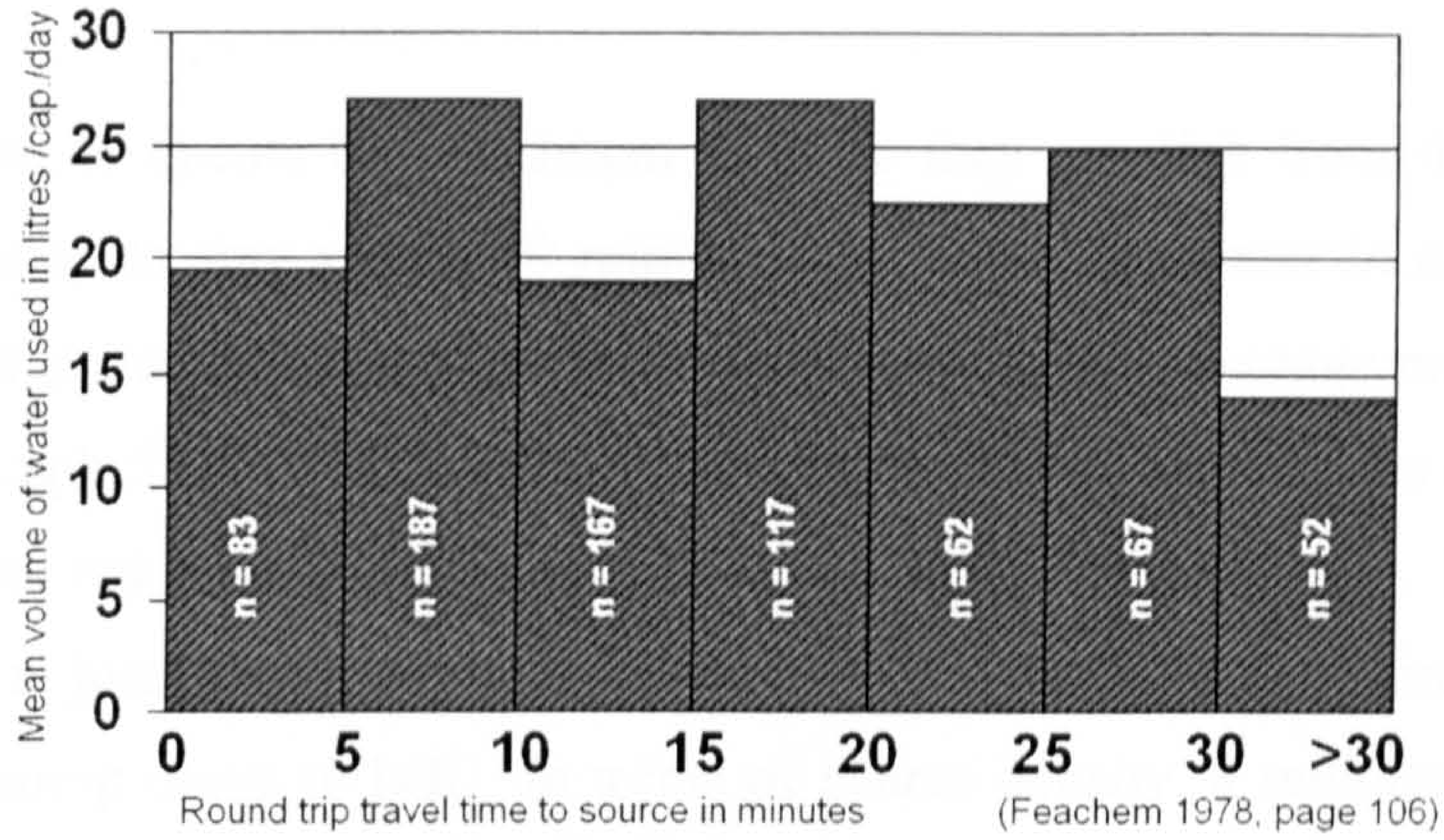
On the contrary they found that up to one mile (≈1.6 km) the amount of water collected was the same and then dropped once the source was more than one mile away (see Graph 4.3).



Graph 4.4: Water volume collected versus source distance for un-piped rural areas

Feachem et al. (1978a) found similar results but expressed the distance as collection time for a round trip (Graph 4.6). When comparing the two graphs, it is possible to see that the drop in Feachem's graph is around 30 minutes for a round trip while White's has a similar drop at 1.6 km.

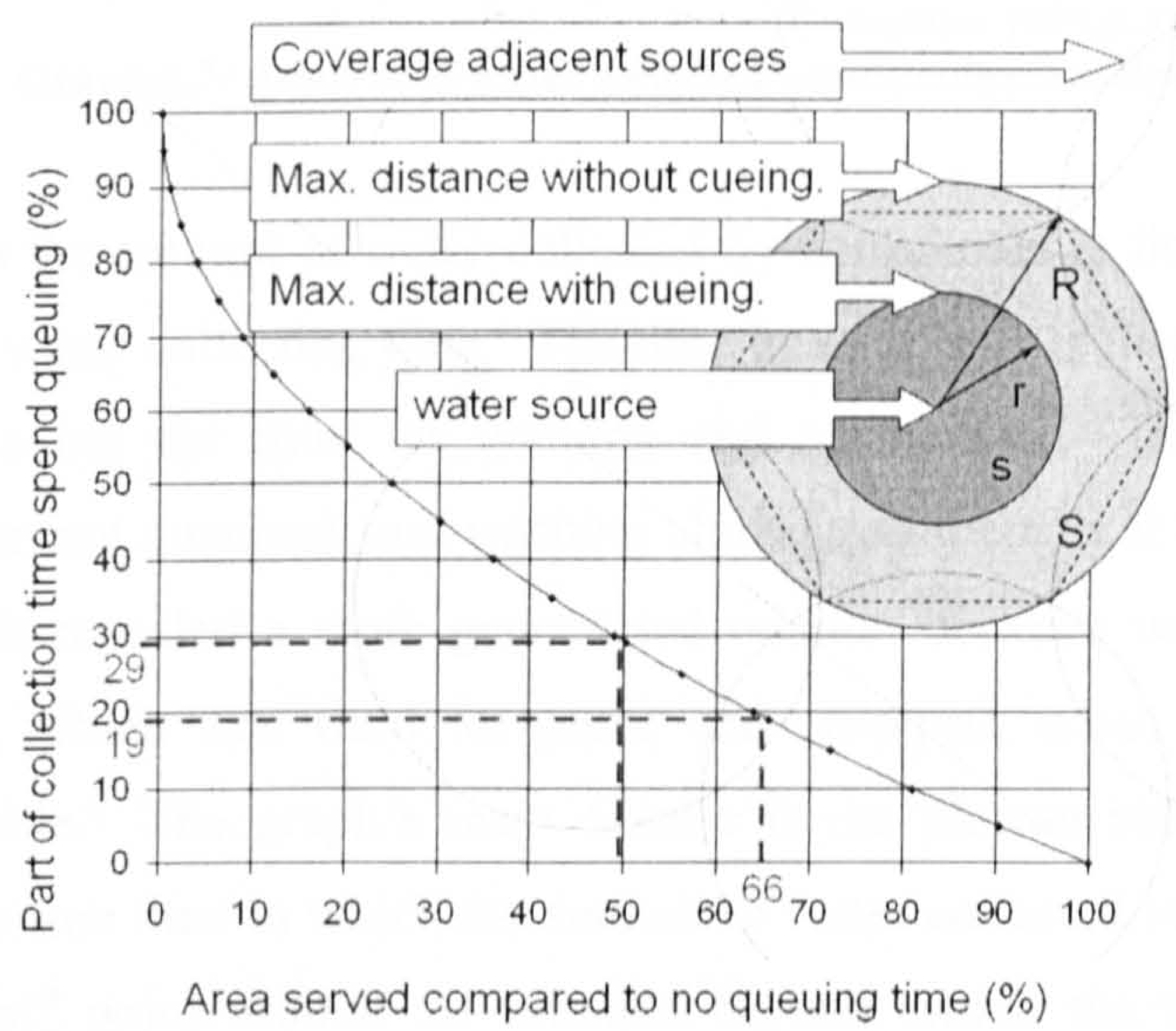
WaterAid Tanzania recommends the use of "*time to fetch water*", suggesting that it is a more useful indicator than "*distance to water source*" (Marshall 2002). Time reflects more accurately the accessibility of a source because in many cases "*considerably more time is required than distance would imply*" (Thompson 2002).



Graph 4.5: Volume of water collected versus the time required for one round trip

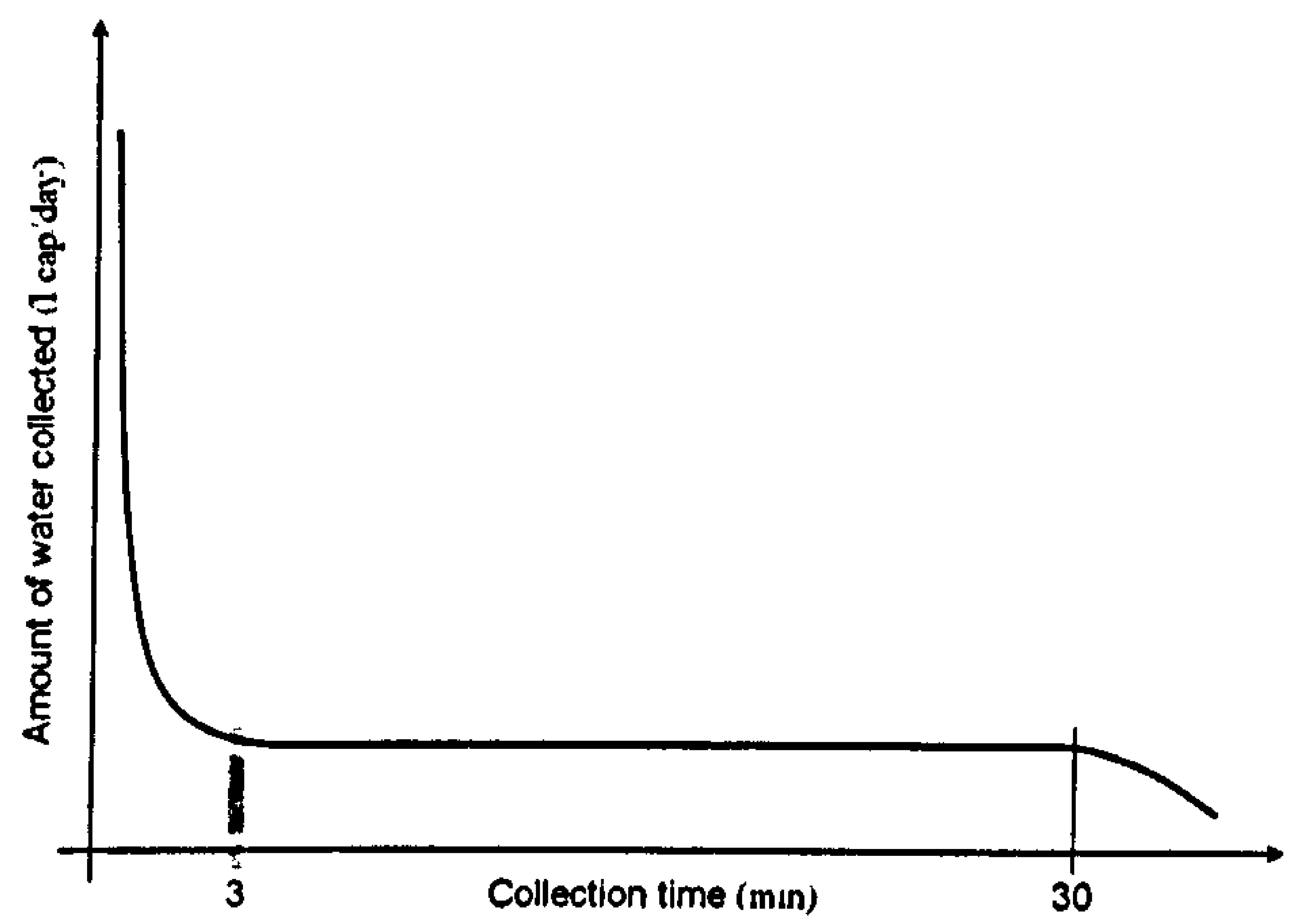
In a comparative study of 16 sites in nine East African urban centres covering 30 years Thompson (2000) noticed that the average collection time had tripled, while in some cases the average distance travelled to the water source was reduced. Habitat (2003) noted a similar reduction of distance to water sources while in many rural settings, the collection time increased. The discrepancy between distance and time is mainly due to queuing at and intermittency of the water source.

To get an idea of the impact of queuing on the impact of water coverage, imagine a flat area in which people could walk straight to the water source. Assume that time for filling their containers is ignored. Let the maximum distance to the source be 1.6 kilometres as in Graph 4.6 or 30 min in time as in Graph 4.5.



Graph 4.6: Relation between collection time and coverage of water sources

If people need to queue, the maximum distance they can live from the source will have to decrease to stay within 30 min limit for collecting water in one round trip. This means that queuing at a water source will reduce the coverage area that source can serve (Graph 5.6). With a queuing time of just below six minutes or 20% of the collection time reduces the coverage area of that source by one-third! If the queuing time goes up to just below 8 minutes which is 29% of the collection time the coverage area of that pump drops to half. In terms of source density, 8 minutes queuing will require twice as many pumps to cover the same area. In reality, more sources will be required because it will be impossible to reach the pump as the crow flies.
Studies such as Feachem et al. (1978a), White et al. (1972) and Thomson et al. (2005) allowed Cairncross and Feachem (1993) to postulate Graph 4. below.



(Cairncross 1993,p.53)
Graph 4.7: Amount of water collected versus collection time

Graph 4.7 gives the amount of water collected by households in litres per capita per day against the water collecting time. The time in the *x*-axis is that required for one round trip including the time for queuing and abstraction. The time spent on socialising (when not queuing), and washing clothes and utensils at the water point is not included. It revealed a more generalised relation between water quantity and collection time, which was valid for piped and un-piped, urban and rural, water sources worldwide. The graph's main feature is the plateau between ±3 and 30 minutes of collection time in which the amount of water collected varies little. There is a clear cut-off point around 30 minutes beyond which the amount of water collected drops. Collection times below ±3 minutes most likely indicate piped water provision, such as in the yard or the house but that cut-off point is less clearly defined.

Depending upon factors such as cultural and climatic factors the plateau represents different amounts in the quantity of water collected, which is why the graph is often published without figures on the *y*-axis.

	Distance (m)		Return time (min)		Number of trips	
Household type	1967	1997	1967	1997	1967	1997
Newly un-piped urban		96		14.4		4.5
Same site un-piped rural	484	622	16.6	25.3	2.5	3.8
Same site un-piped urban	230	204	9.8	21.4	2.6	4.0
All sites	428	459	15.1	23.0	2.6	4.0
Increase in %		+7%		+53%		+54%

(Adapted from Thompson 2002,p.60)

Table 4.10: Changes in access for un-piped households in Eastern Africa over three decades

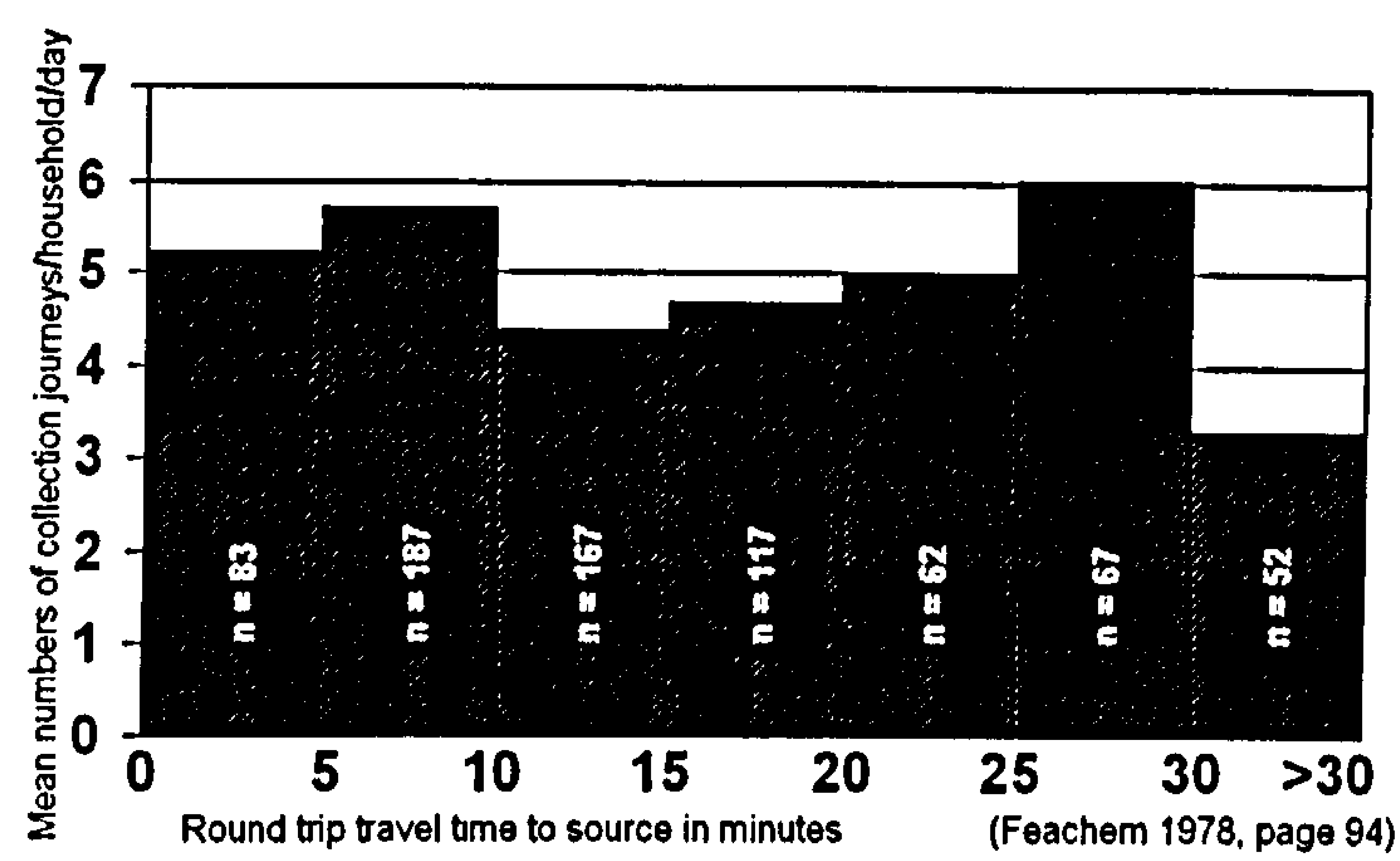
The importance of collection time has been recognised by DHS as their manual states "*A question on the travel time to the source of water is included to obtain an indirect measure of the amount of water available*" (ORC Macro 1995, 2002). Unfortunately this information is not taken into account in the calculation of JMP access figures as the JMP doubts the accuracy of the data (Devi 2004).

In situations where people are not used to formal time spans expressed in hours, references can be made to the time required to cook basic food items, such as cooking yam in Malawi (Stoupy 2003).

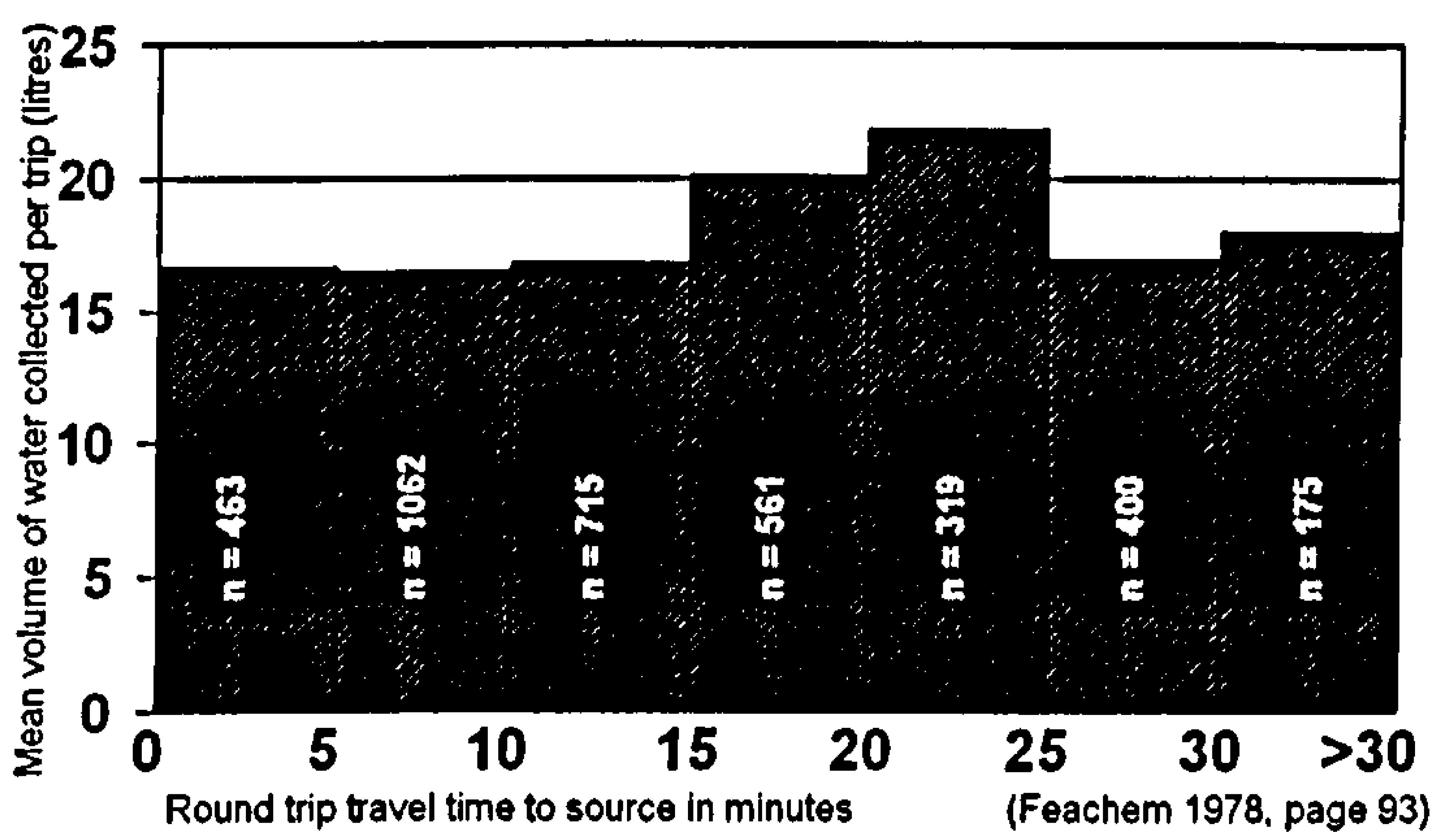
In terms of water quantity and the time spent collecting water, there is not only the distance and the time required for one round trip but also the number of trips (Table 4.10) which determines the amount of water used at the household.

Number of trips per day to collect water

Those living in households, which have no piped household connection, will mostly make multiple trips to collect water. Research in Lesotho indicated that between two-six trips were made to collect household water (Feachem 1978a). While the number of trips reduces when collection journeys take more than 30 minutes (Graph 4.8) the amount of water collected per trip did not change significantly.



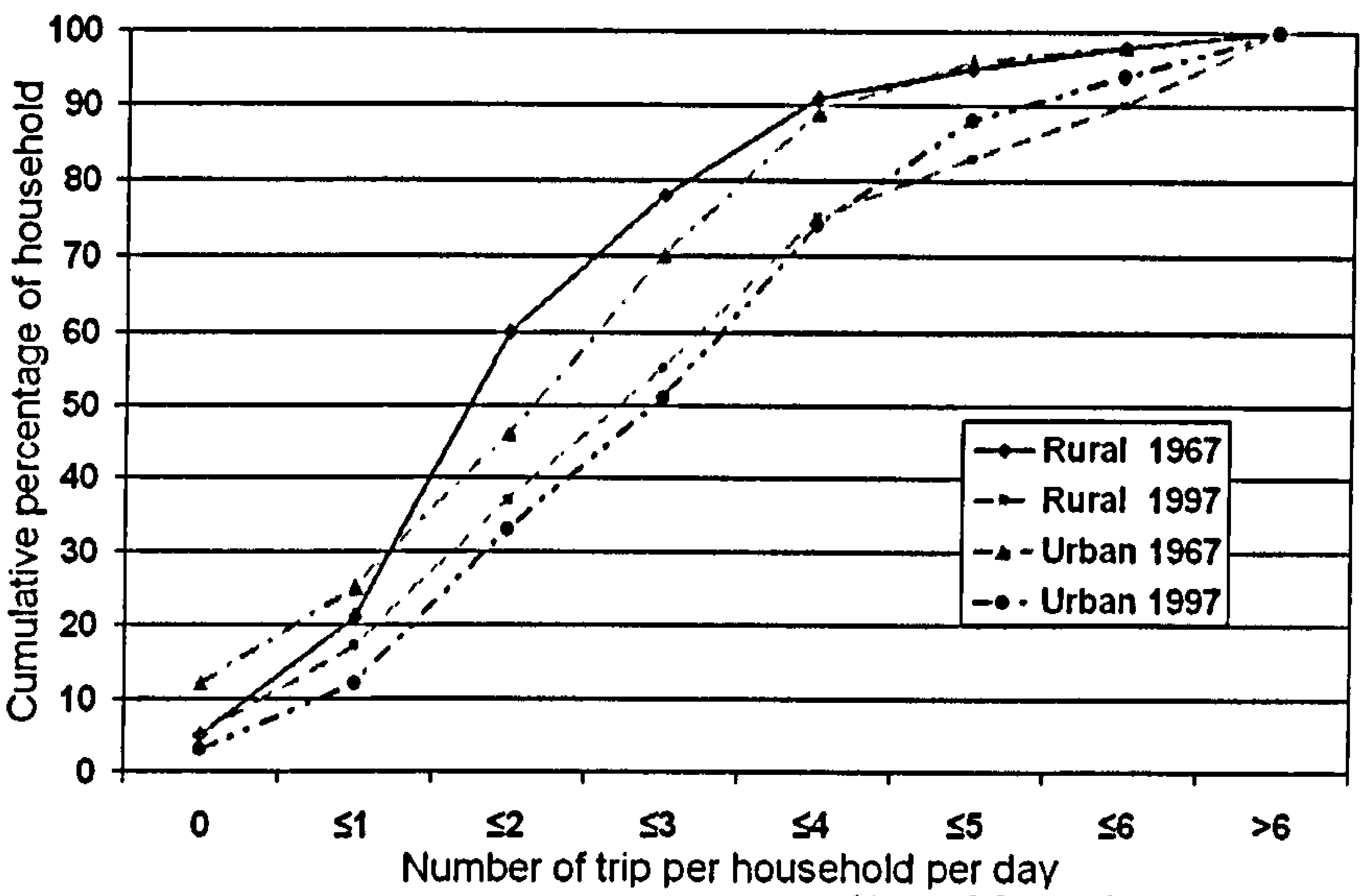
Graph 4.8: Number of journeys in function of the collection time per trip



Graph 4.9: Mean volume of water collected per journey in function of the collection time per trip

Thompson (2002, p.60) looks at the number of round trips for 12 selected sites within Kenya, Uganda and Tanzania. He found a maximum mean number of trips, more than 6, but also showed that the number of trips had increased over time.

If more trips are carried out, they might be an indicator of easy access, intermittent supply or a higher consumption rate, due to water-demanding activities or large families. More trips might also indicate an 'improved' hygiene behaviour rather than ease of access to water. Therefore, the number of trips is not an easy indicator to interpret and will not be considered for the *WaSH* survey.



(Apated from Thompson 2002, p.60)

Graph 4.10: Variation on the number of trips over a 30-year period in East Africa

Cost of water

Cost is an important aspect of access to water. Over the past few decades, the number of people that have to pay for their water supply has increased in large parts of the world (Table4.11).

	DOW I (1967)	DOW II (1997)
Rural	1% (n=315)	11% (n=307)
Urban	53% (n=94)	80%* (n=171)

(The table covers information on selected sites in Kenya, Uganda and Tanzania)
* These include former households with 69% (n=91) and new households 93% (n=80) (Thompson 2002; White 1972)

Table 4.11: Changes to the proportion of people paying for water over a 30-year period.

The cost of water differs between countries and regions and even over time (Table 4.12) which makes it difficult to set a universal acceptable threshold to access based on direct water cost.

Cost varies from source to source (Table 4.13) which undoubtedly has an impact on the household budget. In a study of 12 sites in 10 countries Zaroff and Okun (1984) found that households were spending a median of 20% of their household budget on the purchase of water from vendors.

Cost in US$/m³	Rural areas			Urban Areas			Total		
	1967		1997	1967		1997*	1967		1997
Kenya	0.76	⇗	0.93	1.43	⇗	1.46	0.84	⇗	0.99
Tanzania	1.25	⇘	0.95	1.37	⇗	2.6	1.30	⇗	1.4
Uganda	0.52	⇗	0.71	0.68	⇗	2.5	0.57	⇗	1.3
Total	0.74	⇗	0.84	1.06	⇗	2.46	0.82	⇗	1.22

* These include the same sides as in 1967 and new sites.

⇗ Cost going up; ⇘ Cost of water going down (Thompson 2002; White 1972)

Table 4.12: Changes over time in water prices by country (rural and urban)

	Lowest		Highest	
Water source	US$/m³	Location	US$/m³	Location
Spring	0.42	Urban	0.88	Rural
Hand-pumped well	0.47	Rural	1.90	Urban
Hydrant or standpipe	0.90	Rural	1.61	Urban
Vendor	4.03	Urban	6.44	Rural
Kiosk	1.21	Rural	2.47	Urban

(Thompson 2002, p.70)

Table 4.13: Cost of water by source

Thompson (2002, p.17) found that lowest incomes spend a significant proportion of their income on water. The proportion of household budgets spend on water determines more clearly than direct water costs the constraints to water access. However, it requires collecting data which difficult to obtain in a reliable way during a cross-sectional survey. Moreover direct cost are not the only cost of water, even for those who do not pay for water at all. As Anna Kajumulo Tibaijuka, Under-Secretary-General United Nations and Executive Director of UN-Habitat said, "*There is a myth that water is free... water in not free, it never has been free. Water is carried for hours by children and women, and comes at a cost unless labour is considered of no value*" (Blas 2003; Harch 2003).

Various methods to evaluate cost of water have been used to determine what people are willing to pay for water supply (Fürst 2000; van Zyl 2000). These methods do not only take into account direct cost but also energy required and opportunity cost. The most important opportunity cost for water collection is time, which was discussed on page 105. The choice of water supply involves a trade-off between increased costs and the benefits of time saved (van Zyl 2000). The more arduous water collection becomes the more people are willing to pay for vendor water as an alternative source. The price of vendor water will increase alongside the time and effort required in collecting that water (Cairncross 1992b). According to the Inter-American Development Bank time savings should be valued at 50% of the market wage rate for unskilled labour in the local economy (van Zyl 2000). Although there is no empirical basis for this 50% cut-off, estimates of the value of time from studies of people's transport choices in developing countries indicated that travel time savings is evaluated by people at less than their market wage rate (Bruzelius 1979; Yucel 1975). Time saved for water collection is however valued at closer to 100% of the market wage rate for unskilled labour. The value implicitly attributed to time by a household can be obtained by dividing the amount they pay to a vendor for bringing water by the time saved from collecting it (Cairncross 2004). In rural Kenya, Whittington et al. (1990) found that this value was US$0.38 per hour which is very close to US$0.35 per hour these household could expect in average in wages. Other research confirmed that the value spent on collecting water is close to the market wage rate for unskilled labour in the local economy (van Zyl 2000).

The impact of the cost of water for the poorest urban household is substantial as it typically spends more than 90% of their household budget on food; the money they spend on water is as a result sacrificed from their food budget (Cairncross 1991).

The way water is paid, such as per *collection*, per *volume* or per *period* (day, week or month), can also have an impact on how much water people use. When payment is per volume people can save money by not collecting water, particularly if payment is per collection. This can be compared with a fixed rate per time period during which people collect as much as they can. However no literature could be found on this issue in relation to its impact on 'access' to water. In the initial *WaSH* survey no information was collected on water cost. The reason for this is that direct costs are difficult to compare in a meaningful way over time and among different areas, because they are different according to context and no universal cut-off value can be set. Collecting more information on income and the total household budget would make such information meaningful but it is difficult to achieve this in a cross-sectional survey during a minimal contact time with the interviewee. Even if this information could be collected it ignores the opportunity cost, in which water collection time plays an important role. Collection time as discussed on page 105 is already included in the *WaSH* survey. When buying water from itinerant water vendors the cost are generally high while collection times are low. However water from these vendors has already been excluded as an 'improved' source on the basis of water quality, quantity and cost. While the cost of water is a major factor in access to water, cost data is difficult to analyse and is unlikely to contribute significantly to the information already collected by the *WaSH* survey

Water quality

WHO considers four different quality aspects to drinking-water: microbial, chemical, radiological and acceptability (WHO 2004a).

Microbial

According to WHO (2004a) "*experience has shown that microbial hazards continue to be the primary concern* [regarding water quality] *in both developing and developed countries.* "*In general terms the greatest microbial risk is that associated with human and animal faeces…* (WHO 2004a). Therefore, good microbial water quality can be based on the selection and protection of the water sources used.

Securing microbial safety of drinking-water supplies relies on the use of multiple barriers at various stages from catchment to consumer, to prevent the contamination of drinking-water or to reduce the contamination levels not injurious to health (WHO 2004a). WHO's preferred strategy is a management approach that places the primary emphasis on preventing or reducing the entry of pathogens into water sources and reducing reliance on treatment processes for removal of pathogens (WHO 2004a). This makes the type of source and its protection a suitable proxy for water quality, as discussed on page 92.

Chemical

There has been increasing recognition that only a few key chemicals cause large scale health effects through drinking-water exposure (WHO 2004a). These include

Fluoride and Arsenic which can occur naturally in the environment. Other chemicals, such as lead, selenium and uranium may also be significant under certain conditions. Measurement of chemical water quality at the household level is complex, whether it is carried out through field testing or by taking samples for specialised labs. Chemical contamination such as Arsenic in Bangladesh is often a regional problem, and requires special attention and approaches. Assessing chemical contamination is only justified if there is a suspicion of chemical water quality problems, for example, if a region is known for such problems. Chemical water quality should be considered as an additional question in the survey when the survey is done in a region where chemical water quality is a concern. As it is not part of this thesis' core questionnaire, chemical water quality will not be discussed further in this document.

Acceptability

According to WHO, water should be free from taste and have a visual appearance and odour that would not be objectionable to the majority of consumers (WHO 2004a). This indicator is relatively easy to obtain, but was not considered for inclusion in the *WaSH* survey. Assessing water quality in such a way would be an emic perspective, which because it relies principally upon the user's senses is difficult to standardise. Moreover some households could object to, for example, chlorine in the water or the tastelessness of pure water, which would confuse the outcome of an 'universal' indicator.

Household water treatment

Initial impressions would assume that all activities reducing pathogenic load onsite are beneficial to the consumer, even if they only show awareness or concern on the part of the user for drinking-water quality. Such home-based water treatment will only offer a health benefit if there is a significant intake of pathogens through drinking-water. However studies show that while hundreds of faecal coliforms can be found in 100 ml of water, thousands or even hundreds of thousands can be found in every gram of weaning food, within the same households (Cairncross 1995). Moreover, home treatment of water is not always reliably carried out. In that respect, home or point-of-use treatment should not be considered as leading to 'improved' water. Reducing pathogens in drinking water requires efforts which is not always in line with the proportion of the daily pathogenic intake from drinking-water.

Disinfection is the most common drinking-water treatment method and is an effective barrier to many pathogens, especially bacteria. It should be used for surface waters and contaminated ground water according to WHO (2004a). Chemical disinfection of a faecal-contaminated water supply with chlorine will reduce the overall risk of disease but not render the water safe even if residual chlorine is present. Moreover, *ph* and turbidity might render such treatment inefficient. Various studies showed that chlorination at the household level has little effect (Jensen 2003; Kirchhoff 1985). If there are two types of water stored (drinking/treated water and non-drinking/un-treated water) at the household level it seems that there is little rigour in their dedicated use (Hoque 1995; Zeitlyn 1994) which makes this distinction at household level considerably useless. Treatment of drinking water at the household also runs the risk of transforming the responsibility of water treatment from the provider to the user, which increases overall water treatment cost. It could also increase the number of people who consume untreated water as they cannot afford or do not have the technical knowledge to treat their water.

Water quality testing

There are different ways of testing water to obtain a clearer idea of the quality of the water used. In most situations, quality will be secondary to quantity, which consequently does not justify spending extra efforts and resources on water quality analyses. 'Quick' water testing could be done with tests such as Turbidity, Colilert test, improved H_2S strips or dip-slides, but they would all take time and cost money. Also, a survey design with indicators based on this type of testing will be less useful if the testing equipment is not available due to access or funding. If there are known local problems of chemical contamination, tests such as those for the detection of *As*, *Fl*, *N* can be used. However, water quality testing should be kept optional and as a result it has been excluded from the core list of *WaSH* indicators. UNICEF and WHO are conducting a pilot study to develop a workable water quality testing protocol for the future. The pilot study's results are expected by the end of 2006.

According to WHO/UNICEF, if water quality could be measured "*the proportion of the population using safe drinking-water is therefore likely to be lower than using improved water sources*" (WHO/UNICEF 2004b,p.23).

Water quantity versus quality

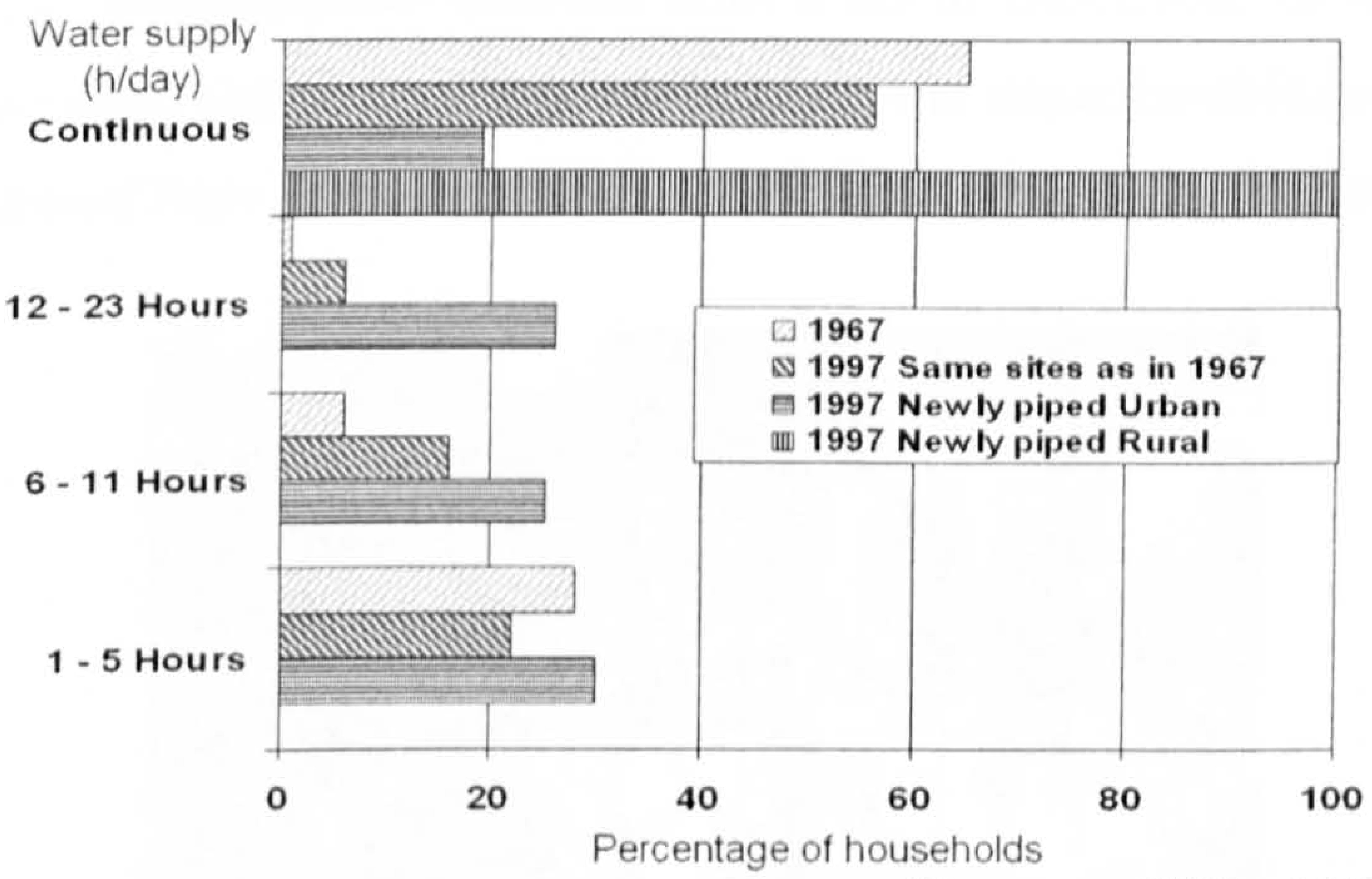
Most benefits from water will be obtained when large amounts of water of a good quality are available. When resources are scarce, public health professionals generally recognise the greater importance of access to water in quantity for hygiene, rather than the quality of that water (Cairncross 1995, 1997; Esrey 1985; Esrey 1990). Studies on the impact of water quality are mainly based upon quality measurements made at the source or collection point. However, research shows that the degree of faecal contamination of water increases during transport to the household (Clasen 2003). There is also increasing evidence that improving water quality at the point of use has a positive health impact (Clasen 2004b; Conroy 2001; Iijima 2001). This is regarded by some as proof that water quantity might be more important (Fewtrell 2005), but such benefits should increase regardless as a result of improved access. This is because people will use more water with better access, thus reducing the water-washed transmission relative to the water-borne transmission. While data supports the theory of increasing health benefits from water quality for people that have at least 15 litres of water per capita per day, there are reasons to believe that these benefits are reduced when access levels to water reduces the available amount of water (Clasen 2006). However at this time not enough data is available to substantiate this (Clasen 2006). Systematic reviews and meta analyses like those of the Cochrane Library infectious diseases group (Clasen 2004a) and field research will be needed to clarify these new findings and examine if these are in conflict with the current paradigm.

"*All infections that can be spread from one person to another by way of water supplies may also be more directly transmitted from faeces to mouth or by way of dirty food. When this is the case the infections may be reduced by the provision of more abundant or more accessible water of unimproved quality*" (Bradley 1980,p.12). Questions of quantity versus quality of water look more for a minimal level to sustain life over the more complex issues surrounding the quality of life. Indicators for measuring access to water typically focuses on health benefits alone, which leads to a failure to capitalize on the benefits that catering to multiple needs can bring (Smits 2005; van Koppen 2006).

Reliability of the water supply.

General Comment 15: The Right to water (arts.11 and 12 of International Covenant on Economic, Social and Cultural Rights) stipulates that in regards to availability, "*the water supply for each person must be ... continuous for personal and domestic uses*" (UN 2002). Not all water sources have water available all of the time. Some sources are seasonal, as will be discussed later, while some groundwater sources might not supply the amount of water that people aim to abstract. The biggest source of unreliable supplies however is piped networks. No water distribution network is free from leaks, but as long as the network is operating at the correct pressure, the likelihood of pollution entering the network is low. If, however, the network pressure drops, pollution can penetrate the distribution network. If the source becomes intermittent, the risk of pollution increases with each cycle of low pressure (LeChevallier 2003). For that reason, intermittent piped water sources could be considered not improved drinking-water sources on the basis of water quality. There is, however, insufficient data to indicate whether pressure transients are a substantial source of risk to water quality.

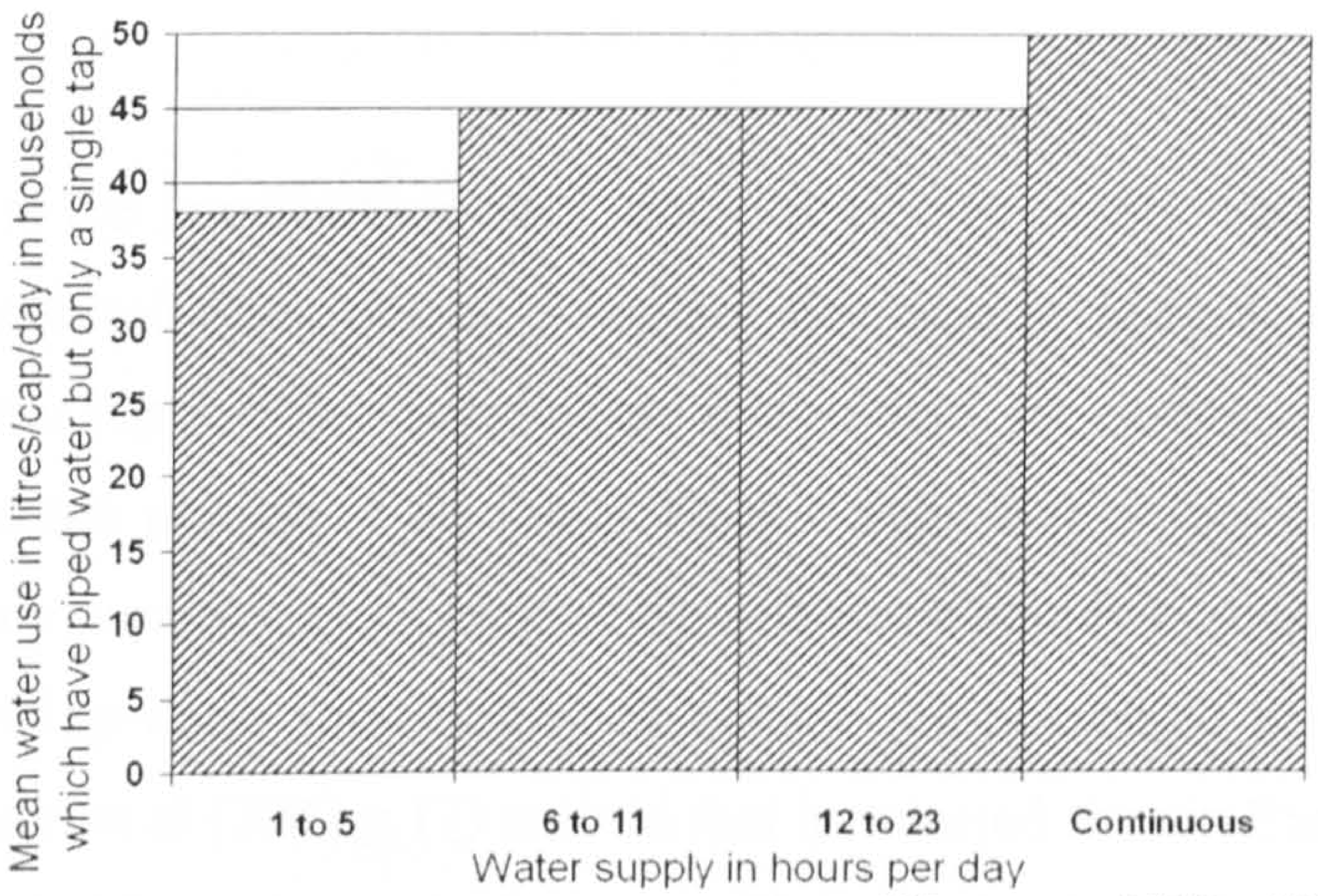
The biggest problem with intermitted water supply is that when the water pressure is low, supply of that water decreases or cease. Graph 4.11 demonstrates the extent of the problem for Eastern Africa as well as the growth of this problem over the past few decades.



(Thompson 2002,p.100)

Graph 4.11: Reliability of piped water supply in Eastern Africa

Graph 4.12 shows that such intermittence reduces the amount of water collected. Unreliable supply is expected to become the main contributing factor to the deterioration of access to water supply in the decades to come, particularly in urban areas (UNICEF 2002).



(Thompson 2002,p.100)

Graph 4.12: Mean water volume/cap/day collected in function of intermitted supply.

Although intermittence is a problem in the level of access to water, it is its unpredictability which is a bigger concern (Thompson 2002,p.56). If intermittence is predictable and all households can collect water within the timeframe, the source is available. Therefore, intermittence might not impact significantly on the collected water quantity. Unpredictable sources with a small timeframe of availability will increase water collection time. If availability become unpredictable people might pay somebody to guard their container while attending to other tasks (Figure 4.6).

Figure 4.6: Queuing for water in India

This would lead to increases in direct water cost. As a result, a question to elicit data on the intermittence of water supply will be included in the questionnaire. Similarly, water storage capacity at the household could be another indicator on the reliability of the water supply as will be discussed below.

Water storage

Water storage at the household is very common among people who have to collect water from communal water points. They are also used by households connected to direct piped water supply when supplies are intermittent, for example, only delivering water during certain periods of the day. Water storage is therefore a necessity, both for those who are connected to a non-continuous water supply system and those who depend on drinking-water sources located outside the household perimeter (Jensen 2002). Thompson et al (2002,p.17) noticed that in selected sites in Eastern Africa the number of households storing water to cope with intermitted piped water supply went up from 3% to 90% over a 30-year period. The physical size of water storage could be an indicator for the reliability of the supply but it could also indicate a high consumption rate, be it for commercial (brewing, livestock, etc) or domestic (hygiene behaviour) reasons. Water can also be stored for other reasons such as in hot climate conditions, where even households with continuous water supply will store water in traditional clay pitchers to keep the water cool (Jensen 2002).

Water storage at the household for whatever reason constitutes an additional shackle in the supply chain, as shown in Figure and Figure , which can become a potential cause of pollution (Clasen 2003). The pathways of in-house contamination of stored water are referred to by Cairncross et al. (1996) as *domestic domain* transmission, while *public domain* transmission corresponds to pollution directly at the source. Since the work by Feachem et al. (1978b), few studies attempted to separate the microbial contamination of drinking-water in the domestic and public domains in order to quantify their relative magnitude and the results of these studies were inconclusive (Clasen 2003; Clasen 2004b; Conroy 1999; Mintz 1995; Quick 1996; Quick 1999; Swerdlow 1992; VanDerslice 1993). Jensen et al. (2002) showed that domestic domain contamination of water is only relevant when the water source is relatively clean (i.e. <100 E-coli/100ml). Storage capacity and amount of water stored in the house also appeared to have a weak association with diarrhoea (Gorter 1998).

In addition, Jensen et al. (2002) noted that pollution in the domestic domain can be attributed to occasional extreme contamination values in the public domain. The type of storage vessel, and in particular its neck size, is considered a good proxy for potential contamination (Jensen 2002; Quick 1996). For example, the narrower the neck, the less harder it is to be polluted, although once polluted narrow neck containers prove difficult to clean (Walden 2005). Narrow neck containers are only essential for dinking but if there are two types of water stored (drinking/treated water and non-drinking/un-treated water) at the household level it seems that there is little rigour in their dedicated use (Hoque 1995; Zeitlyn 1994) which makes this distinction at household level less useful.

Water storage at the household is an important aspect of water supply. However, it does not provide information that has a clear relation with a potential access to water indicator. Although information on storage was included in the field trials it was related to hygiene behaviour, which is discussed later and not to the water indicator discussed here.

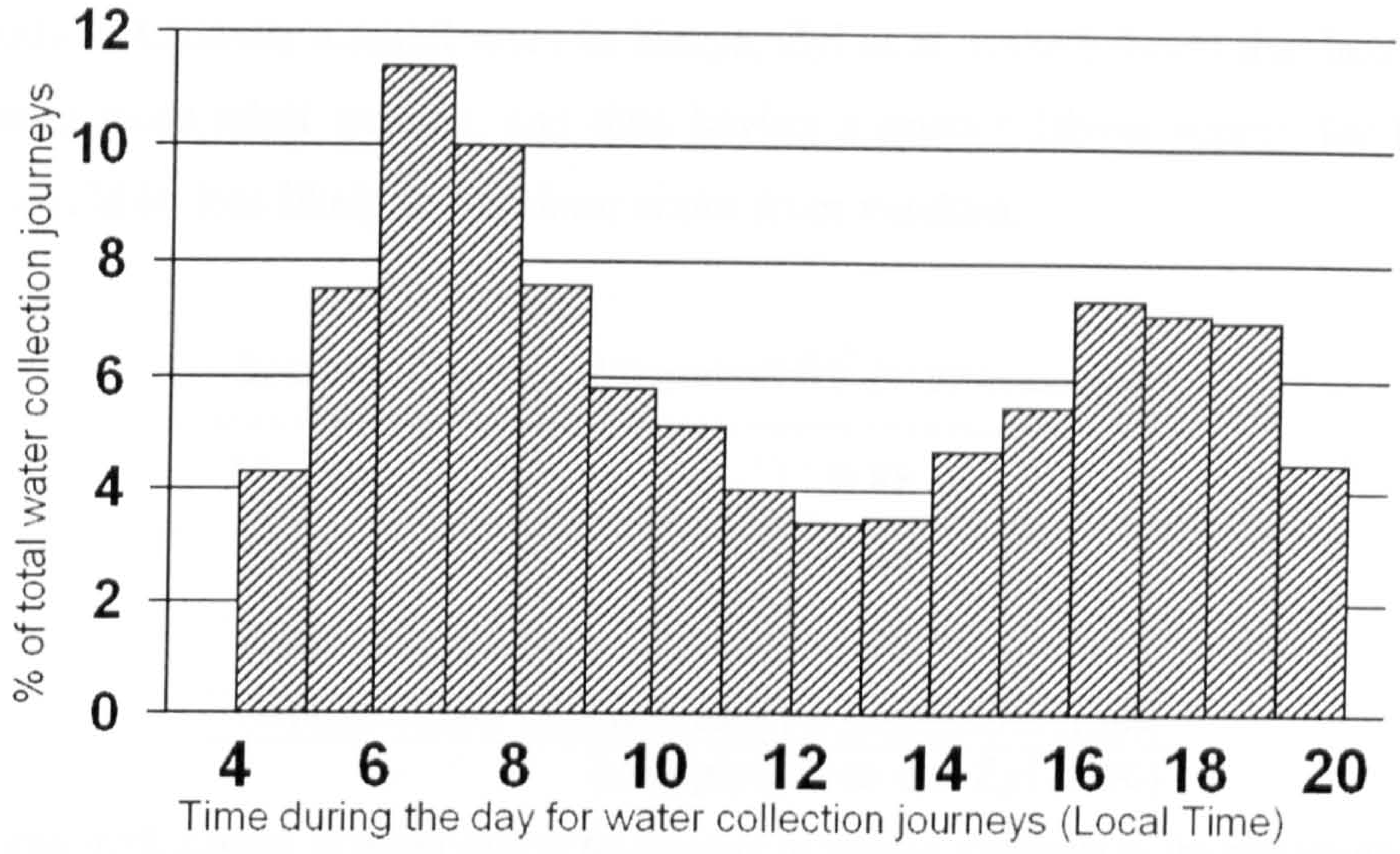
Physical accessibility to the water

Terrain, relief, opening hours and queuing time are important factors in determining whether people have access. With the exception of queuing time, they are difficult to measure. Most of them become more important when the amount of water needed increases, as is the case for non-drinking water. They are also reflected in the time needed to collect water and will for that reason not be included in the survey.

Time during the day water is collected

Water collection time patterns are not well studied. A study in Lesoto showed that in the lowland areas most of the water was collected in the early morning and late afternoon (Feachem 1978a).

During focus group discussions held during the Kenyan survey for this research, people complained that often the pressure only returned to their network late in the evening after demand in the rest of the town declined.



(Reproduced from Feachem 1978a,p.91)

Graph 4.13: Distribution of water collection journeys of the day

However, personal security when collecting water at night then became a problem and the times spent queuing was often lengthy. Moreover, they found the unpredictability of supply an even bigger problem and they wasted time waiting in vain for water pressure to increase.

Person involved in collection

Women or girls are usually the main member of the household burdened with collecting water (Table 4.14).

Water collectors	Area of data collection: Mafeteng Lowlands		Mokhotlong Mountains	
Adult females	65.5	96.3	77.6	96.6
Minor females (< 10 years)	30.8		19.0	
Adult males	1.6	3.7	1.8	3.4
Minor males (< 10 years)	2.1		1.6	

(Adapted from Feachem 1978a)

Table 4.14: Persons within the household involved in water collection in Lesotho

In a study in Ukunda, a small town in Kenya, Zyl et al. (2000) found that households containing more adult women, and thus having a greater labour supply for hauling water, would be less likely to purchase water from vendors.

Source of water	# women/HH* (n=69 households)
Vendor	0.88
Kiosk	1.44
Well	1.78

*Average number of adult women per household available

(Adapted from van Zyl 2000)

Table 4.15: Choice of water source by number of women available in the household.

This question has been included in the new DHS survey questionnaire. But while revealing important information on the discrepancies in the burden of water collection, it does not add to knowledge about the level of access and will not be considered in the survey.

Energy needed to abstract and transport the water.

Where water sources are far away from the household, or water is hand-pumped from a deep aquifer or when the altitude difference between household and water point is considerable, it is likely that the energy in obtaining water is high in regards to their daily calorific intake. In the first *Drawers of Water* publication, White et al (1972, p.93) measured the energy expenditure and converted it to the cost of the staple food used. Thompson (2002, p.67) made identical calculations in a comparative study 30 years later, but noted that ideally opportunity costs in time lost should also be considered as they are probably more important than the costs energy wise. There is no easy way of collecting this data and with fluctuating costs of staple crops over the year it might not be as straightforward to make easy universal comparison. It is however indirectly expressed in the time people need to collect water (Thompson 2002) and so will not be considered as a separate indicator.

Seasonal variations

Seasonal variations in water supply are complicated to assess, particularly among nomadic and semi-nomadic populations. It is difficult to express seasonality in a simple yes or no. If a household has 10 months of access to an 'improved' water source and two months non-access does that mean they have no access according to a *WaSH* indicator? Recommendations that the survey is best held when water is scarce might be a good idea. However the dry season is not necessarily the worst case for access to 'improved' water sources. Timing the survey in a specific season may not always be realistic. Asking these questions during the dry season could lead to recall and strategic bias.

Each survey should be accompanied by a brief description by the survey organiser which should explain the season and the global water situation. The survey will also suggest an optional question which indicates how representative the collected data is compared to the situation over the whole year, as demonstrated in Chapter 7.

4.2.2 Defining the WaSH water indicator

On the basis of the information above an initial water indicator was determined with a goal to measure *access to an 'improved' water source* as defined for the *WaSH* survey in paragraph 4.2. Figure 4.7 shows the initial decision tree as submitted to the WSSCC monitoring task force on 18 June 2002 (see documents in Annex A.1). Major changes were made following comments and feedback regarding the suggested water indicator in relation to the 'protection' of the water source. It was suggested that additional questions on the level of protection were included to specify what was meant by protection.

In the same way, members of the JMP Technical Advisory Group (TAG) participating in the meeting argued that using the presence of a concrete wall around a spring does not constitute a suitable protection from contamination. Such questions, according to some members of the TAG, should not be included because the surveyor would not be able to judge how adequate different examples of water source protection are.

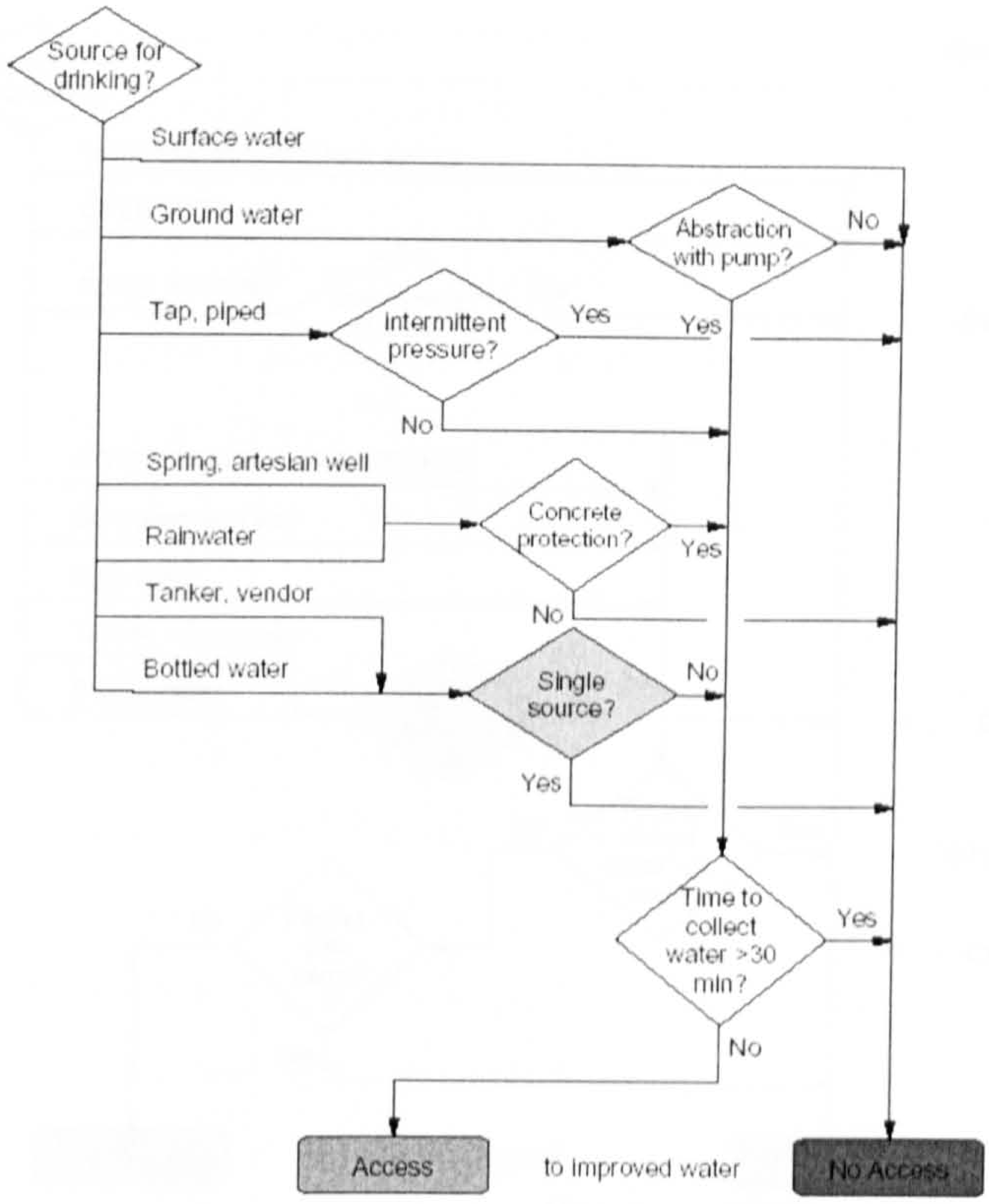
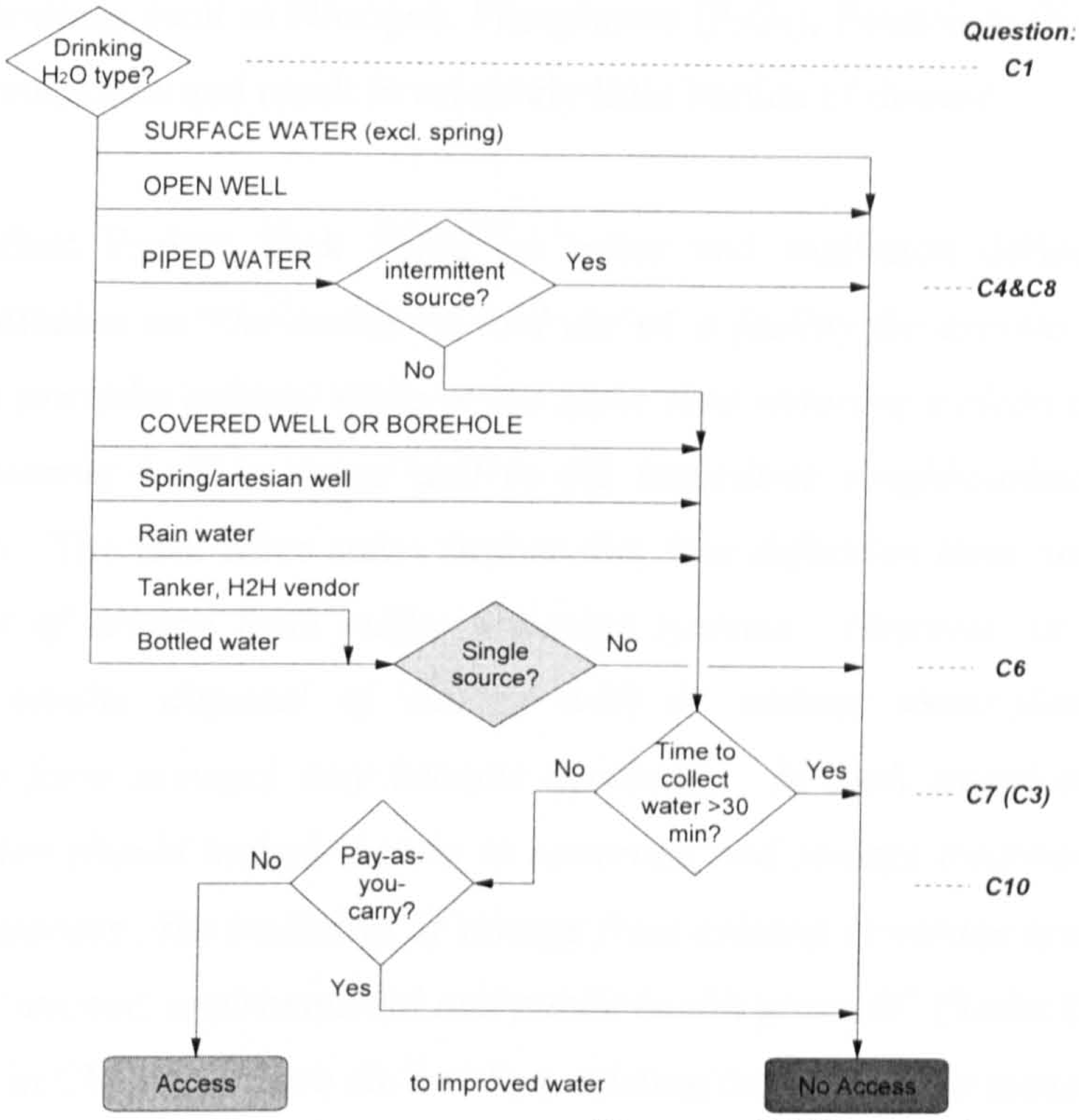


Figure 4.7: Initial decision tree for *WaSH* water indicator (Bostoen 2002a, p.16)

This argument, however, is harder to maintain because to provide the data in surveys such as the DHS and the MICS surveys, on which the JMP relies, the interviewee has to chose between protected and unprotected sources without any of the surveys defining what is meant by 'protected'.

The modified decision model for the indicator used in the first field trials is shown in Figure 4.8. It also includes a question on water payment which the WSSCC monitoring task force felt was missing from the survey.

Annex B.1 contains the first version of the survey questionnaire rationale, conclusion assumption and remarks for each question while Annex B.2 contains only the questionnaire. Annex B.3 contains the argumentation about the indicator partly discussed above. Changes made to the questionnaire following peer review can be found in Annex C, which also contains the questions referred to in Figure 4.8. The questionnaire in Annex C not only contains conclusions, rationale assumptions and remarks, but also details of the questions' origins.



(Bostoen 2002a, p.41)

Figure 4.8: Decision model for the *WaSH* water indicators as used in the first field trials

4.3 Defining access to 'improved' sanitation

While identifying important components regarding water, sanitation and hygiene practices, WHO concluded that among the three key messages was '*Safer disposal of human excreta, particularly the faeces of young children and babies, and of people with diarrhoea*' (WHO 1992). The main reason for controlled disposal of human excreta is its central role in the transmission and spread of a wide range of communicable diseases (Feachem 1983). The disease-causing agents (pathogens) of these infections are mainly found in faeces and rarely in urine[6]. While faecal oral transmission contributes significantly to overall morbidity and mortality (WHO 2004b), there are a few infections such as hookworm and shistosomiasis, which can penetrate through the skin (Feachem 1983). To a lesser extend there is the risk of

[6] The three principal infections leading to significant pathogen load in urine are urinary schistosomiasis, thypoid, leptospirosis (Feachem 1983)

high concentrations such as Nitrogen, Phosphorus (P_2O_5), Potassium (K_2O) but these are not communicable and result in relatively little burden of disease.

The Millennium Project Task Force on water and sanitation defines access to improved sanitation as "*the access to, and use of, a facility for excreta and sullage*[7] *disposal that provides privacy while at the same time ensuring a clean and healthful living environment both at home and in the immediate neighbourhood of users*" (Sachs 2004). The task force states further that "*the definition does not yet include the treatment of sewage from public sewerage systems. However, in high-density slum areas on-site disposal of sullage with or without water-flushed excreta (combined to form sewage) may become necessary. In such situations, access to basic sanitation should include access to sewerage and sewage treatment plants In other circumstances , the treatment of sewage from existing sewerage systems may be justified on economic, environmental and public health grounds*" (Sachs 2004,p.61). As discussed in Chapter 3 there are no clear existing definitions for measuring access to 'improved' sanitation. For this reason the *WaSH* survey methodology will, for the purpose of measuring, define access to 'improved' sanitation as sanitation that:

- **hygienically separates human excreta** from human contact until it loses its pathogenic load;
- is **private or shared** but NOT public;
- is likely to be used regularly in a **convenient** way.

Table 4.16: *WaSH* definition of access to 'improved' sanitation

Breaking the faecal-human transmission route (WHO/UNICEF 1996) could be a more accurate way of describing the goal of sanitation but this constitutes more a theoretical than practical definition.
The above definition results in two initial aspects, ①use of the latrine, (private, shared and public) and ②proper technology, which are both discussed below. Positive impacts of sanitation facilities can only be expected if these facilities are used, so convenience plays a mayor role in 'improved' sanitation. The section below reviews

[7] Defined as domestic sewage resulting from bathing and washing of dishes and clothes in house

various aspects regarding access to sanitation and discusses their significance towards an access indicator.

4.3.1 Aspects determining access to 'improved' sanitation

The main aim of sanitation is keep excreta out of the human 'environment'. This can be achieved by different sanitation technologies which in relation to the faecal pathogens can either **contain** or **disperse** them. The way excreta are contained will be determined by the extent to which the pathogenic content is **removed/destroyed.** This is important because the chemicals found in excreta, and particularly in urine, are a useful natural fertiliser. Technologies that focus on the **reuse** of excreta may not contain or destroy the pathogens enough to lead to individual or even public health benefits.

Containment at the household level might impact at a community level, for example, when effluent is piped out of the dwelling into a river where it can pose a health hazard downstream. The same applies to sewerage systems where the effluent is not properly treated. Even if technologies are perfect, they have to be used appropriately. Materials used for anal cleansing should be handled and disposed of adequately, while handwashing after defecation is an integral part of keeping excreta out of the environment.

Containment of pathogens is the main etic reason while the box below reveals example emic reasons for sanitation as highlighted during a study carried out in the Philippines:

1. lack of smell and flies;
2. cleaner surroundings;
3. privacy;
4. less embarrassment when friends visit;
5. less gastrointestinal diseases.

(Cairncross 1992a,p.5)

Box 4.1: Emic reasons for having sanitation in order of priority in a Philippine study

The factors in Box 4.1 are also important in relation to the technical aspects discussed previously because they will determine the households' willingness to use the facilities to which they have access. The contribution these factors, which also include technology, ownership, cleanliness, use, proximity of handwashing facilities, abundance of flies, sustainability, make towards a *WaSH* sanitation indicator are discussed below.

Type of technology used

There are several ways of classifying the different types of technologies in use and available. Table 4. shows various excreta disposal technologies classified in a two by two table, placing wet/dry methods (use of water or not) against on-site or off-site disposal of excreta.
The options in brackets in Table 4. are those that are not recommended, mainly because they require handling of fresh faeces, are technologically 'complex' or high in cost.

	On-Site	Off-Site
Dry	Pit or borehole latrine VIP[8] latrine Twin pit latrine (Urine diverting dehydrating) (Compost toilet)	(Bucket latrine) (Vault toilet)
Wet	Pour-flush toilet Septic tank + soakaway (Aqua-privy)	Sewerage: • Small bore • (Conventional)

(...) not recommended
Cairncross, lecture notes for Diploma for Tropical Nursing LSHTM (2001)

Table 4.17: Excreta disposal technology classifying on/off site and dry/wet technology

Another way of classifying excreta disposal methods is to divide systems up in technology types according what they do to pathogens:

- Dispersing: allows diffusing of pathogens;
- Containing: stop diffusing of pathogens;
- Destructing: contains and renders pathogens harmless.

[8] VIP stands for Ventilated Improved Pit latrine which is a very design specific latrine (Cairncross 1993)

Health protecting **"Pathogen containing / destructing"**	**Health threatening** **"Pathogen dispersing"**
Connection by non-leaking sewer to operational sewage treatment system which has achieved a specified effluent standard.	Connection to a sewer which leaks or has no or a non-functional sewage treatment plant, or when specified effluent standard is not achieved.
Non-leaking septic tank or aqua-privy with at least one metre of soil between the tank bottom and the water table, connected to a suitable sewer, infiltration pit or infiltration trenches.	Septic tank or aqua-privy which: • leaks or; • is < one metre above the water table or; • is connected to inappropriate sewers or; • has an inappropriate infiltration pit / trenches.
Pour-flush latrine, simple pit latrine, ventilated-improved-pit-latrine (VIP) with a clean easy-to-clean drop hole and the bottom of the pit at least one metre above the water table.	Pour-flush latrine, simple pit latrine, VIP latrine subject to inundation and/or in places where tank base is less than one metre from water table
Urine-diverting double vault desiccating or composting toilets with at least one years storage in each pit avoiding exposure of virulent excreta.	Urine-diverting double vault desiccating or composting toilets which do not avoid exposure to virulent excreta.
Continuous or batched collection systems for diverted faeces/urine so that contact with excreta less than one year old is not possible during transport, processing to render them harmless (e.g. composting, selective fertilising etc.)	Service, bucket or public latrines where contact with excreta less than one year old is possible unless effectively composted or desiccated.
No 'improved' alternative	Open defecation, i.e. flying toilet (in bag and throw away); cat method (dig small hole and cover); overhanging toilets suspended above public surface waters.

Table 4.18: Classification of excreta disposable methods according the level of containment

The different technologies used for latrines all have both advantages and disadvantages. The key measure of interest is how far each technology "*hygienically separates human excreta from human contact*" (WHO/UNICEF 2000).. The classification in Table 4. has a category in the left column which fulfils this criteria. However not all aspects allowing categorisation according to the table are known to the user or can be identified by the interviewer at the household. The section below will discuss if a technology-based classification can be used as a proxy to define suitable sanitation facilities.

Water-based disposal systems

Water-based disposal system such as flush, pour-flush and aqua privies are generally connected to a collection tank and the contents removed by a sewerage network, or treated locally in the septic tank before the contents are also sent to an infiltration area. They can be considered an 'improved' form of sanitation if:

- enough water is available to make the system function properly;
- effluent is properly treated or there is at least no proof of effluent visible neither is there discharge into surface water.
- there are no leaks in the system.

There are so many aspects which are difficult to assess that one can only assume the system is *properly implemented* unless there are clear signs this is not the case. However, identifying clear signs of open discharge will require a longer questionnaire.

Bucket or 'service' latrine

Faeces in bucket or 'service' latrines rely on regular, sometimes daily, collection. In low income countries little technology is available to ensure that it is collected hygienically. This does not only constitute a health risk for the people involved in the collection of fresh faeces, but also to the wider community if transport facilities do not promote proper containment or if there are no appropriate final disposal of the faeces.

Pit latrines

Pit latrines are only an improved form of sanitation if they have a floor and the drop hole is kept clean. Others (e.g. open, and generally, shallow pits) are considered 'not improved'. They are unlikely to be hygienic and are rarely used by young children because of the danger or fear of falling into the hole.

If water and pit-based sanitation is considered 'improved' it is assume that:

- the technology is appropriate for the anal cleansing material used;
- anal cleansing material is properly disposed off.

In the Global Assessment (WHO/UNICEF 2000) an excreta disposal system is:

'improved' when it is a:	'non-improved' when it is:
• connection to a public sewer • connection to septic tank • pour-flush • simple pit latrine • ventilated pit latrine	• service or bucket latrines (manual removal) • public latrines[9] • latrines with an open pit

This limited definition is based on the data currently available in existing household surveys such as MISC and DHS surveys. The questions in the DHS relate more to 'ownership' because the primary goal of the DHS surveys is to determine wealth of the household divided into quintiles. This is reiterated by the JMP, which considers that shared and public sanitation are not improved forms of sanitation. Only households with private facilities using an 'improved' technology are considered to have access. Ownership in relation to access is discussed in more detail in the next section.

Ownership of a latrine

There is no doubt that people owning their own toilet have better access to sanitation compared to those relying on public facilities. Private owner are more likely to use facilities in which they invested. Surveys often examine whether the facility is a **public** or a **private** one. However, ownership is rarely a binary relationship and a third **shared** category is suggested in the following paragraphs.

Public latrine

It is generally assumed that public latrines are less clean than private ones (Wasao 2002; WHO/UNICEF 2000) . This has implications on their potential to *hygienically separate human excreta from human contact* and how willingly people use them if alternatives such as open defecation are available. Both the cleanliness and 'willingness to use' will determine the degree to which these facilities keep pathogens out of the human environment. User fees might be another reason why people resort

[9] Any form of toilet sharing is considered as non-access to sanitation by JMP

to alternative defecation methods which are likely to result in non-contained defecation. Another is long distances required to travel to these public facilities, while having to queue reduces its convenience factor, in particular for young children. Another issue is using public latrines at night, as insecurity is often a problem (Musyimi 2002).

The distance, queuing and cost of visiting public toilets are all difficult to include during visual checks of such facilities in a cross-sectional survey. Moreover, using at the public toilets at night which is a particular concern especially for women (Musyimi 2002) cannot be assessed by observation.

In the *WaSH* survey public toilets will be defined as:

A toilet that can be used by people not known to the household interviewed

Table 4.19: Definition of public toilets used in the *WaSH* survey method

This definition makes it easier to distinguish between public and shared toilets, which are discussed below. Public toilets, due to their inconvenience and also because of their tendency to be unhygienic, will not be considered as "*access to 'improved' sanitation*" in the *WaSH* survey.

Shared toilet (not public)

In the Global Assessment report (WHO/UNICEF 2000), shared latrines were considered an '*improved* form of sanitation'. This was due to the use of existing databases in which it was not always possible to differentiate between shared and private latrines. But according to the Joint Monitoring Program (JMP) (Henderson 2002), shared latrines should not be considered improved. This is because of the risk that shared latrines are more likely to be less hygienic compared to private ones, but also because safe use, especially during the night for women and children, will be more difficult.

Initially the *WaSH* survey excluded shared and public toilets as 'improved' on the insistence of WSSCC monitoring task force's recommendation. However, after the Kenyan survey this was reviewed as discussed in Chapter 7 and Chapter 9.

This is because shared toilets are often used where private toilets are impractical or when they are unaffordable. They sometimes suffer from the same unhygienic conditions commonly found in public toilets. Shared toilets used by multiple families can be kept clean because their use is limited to a number of people all know to each other. As these facilities are more likely to be close to the household they can be included in the visual inspection during a survey. They also are more likely to offer safe access day and night for all users. The definition for *shared toilets (non public)* in the *WaSH* survey is:

A toilet shared by a limited number of households known to the interviewee

Table 4.20: Definition of shared toilets used in the *WaSH* survey method

If the household interviewed does not know all the people, it is likely that too many people use the toilet or the shared toilet is actually a public toilet and should be classified as such. Shared latrines will be considered acceptable if the technology used and a visual inspection during the survey indicates, that the toilet safely separates human excreta from the human environment. It unfortunately does not mean these facilities can be accessed day and night and assessing this might be considered in future.

Private toilet

A toilet used only by members of the interviewed household is considered private. While they tend to be cleaner compared to a shared or public latrine, the interviewer will verify if this is the case by making a visual inspection. This confirms for the purposes of the survey if there really is a toilet and if the technology stated by the interviewee is the one visually identified.
In the *WaSH* survey private toilets are defined as:

A toilet which is only used by the household interviewed

Table 4.21: Definition of private toilet used in the *WaSH* survey method

Through questions and visual observation it should be possible to determine if the latrine is *private, shared* or *public.* The observations are required for shared and private latrines, as households have been known to falsely claim ownership of a latrine. Latrines may exist but not be regularly used, or they may be in use (e.g. by a landlord) but not accessible to all members of the household. It might also be possible that adolescents and adults use them only because of privacy, which might not be considered necessary for small children, who would be allowed to defecate in the open.

Pit emptying technology used.

Even if an on-site system works properly, emptying or desludging will be required. In contrast with bucket latrines, emptying/desludging is done at longer intervals, and apart from more recent deposits, the excreta has over time evolved into a substance with a lower pathogenic load in comparison with fresh deposits. However if there is a congregation of households, one or another household will need to empty its toilet. This regular emptying and transport of faecal matter might pose a risk, because the most recent faecal matter will still be pathogenic. Emptying of pits and collection tanks in low-income areas is common (Figure 4.) and where safer mechanical pumps like the 'VacuTug' (Figure 4.) are available these often do not have access to large parts of unplanned settlements. Some communities rely on seasonal flooding as a much cheaper alternative to emptying pit latrines but there are high health risks associated with flooding.

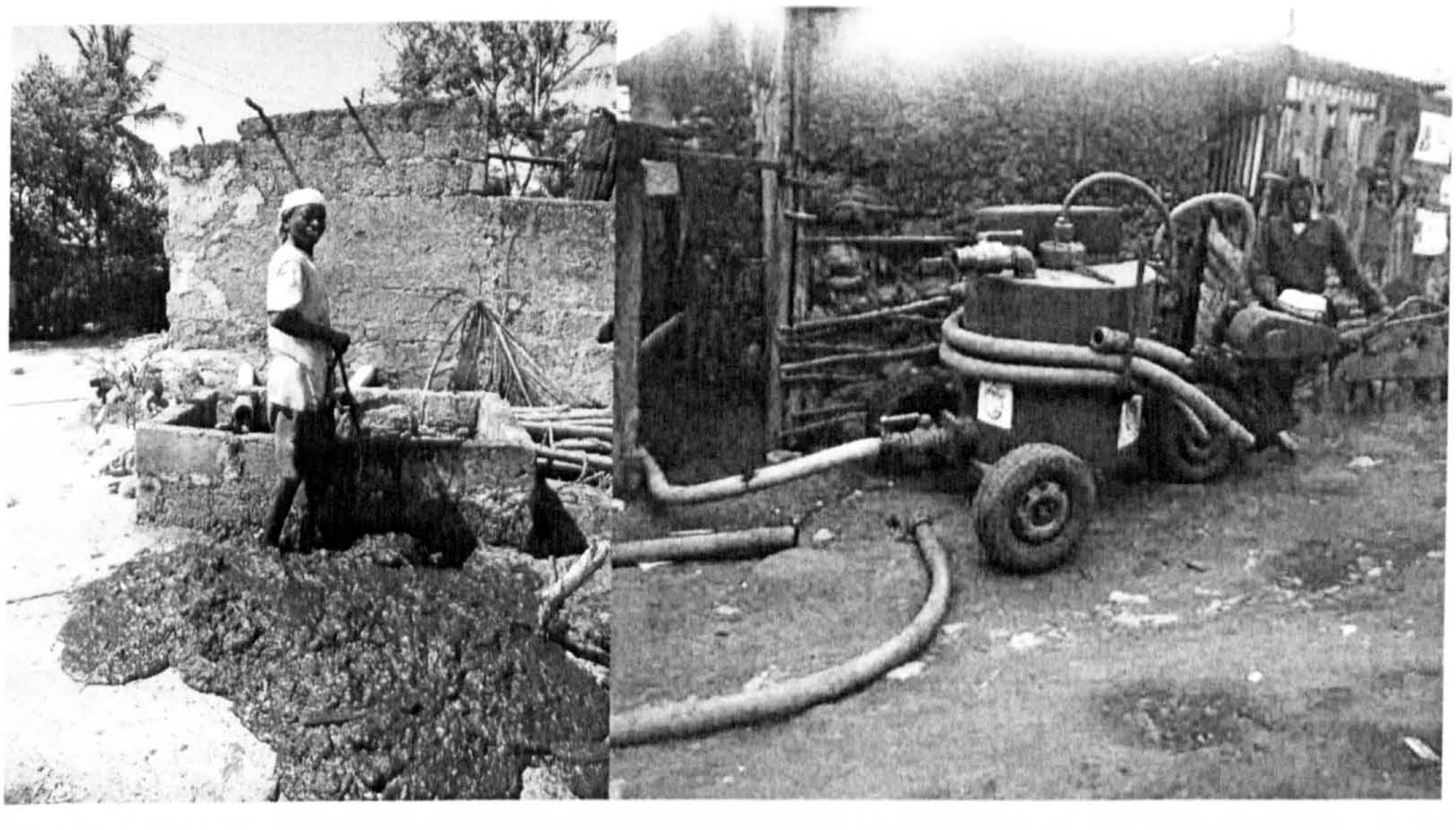


Figure 4.9: Manual and mechanical pit emptying methods for on-site sanitation

Emptying technologies, their cost and availability will contribute to the safe segregation of excreta from the human environment. It would be worth taking into account the whole life cycle of the latrine and the excreta but it was considered difficult to include such information in the survey methodology. Many forms of on-site sanitation take years before any emptying is required. Households might not recall how long ago they use such services and are unable to assess how adequate the excreta was contained at the time. The primary issue for households is considered to be access to adequate sanitation. While the current sanitation coverage remains low, obtaining information on pit emptying technologies is seen as a secondary issue, which becomes more important when sanitation coverage increases. For that reason, information on pit emptying was not considered for the core of the *WaSH* survey .

Cleanliness of sanitation infrastructure

Cleanliness is a very subjective criteria. Here it is related to the likelihood of a user coming into contact with excreta during the normal use of the latrine. While excreta are not always clearly visual or identifiable during such a visual inspection, the examination allows opportunities to cross check other aspects of the sanitation facility such its type, presence or access. Although this will be done during the *WaSH* survey trials, proper care should be taking when training the survey staff to ensure that all observations are comparable.

Handwashing facilities near toilet.

Handwashing after defecation is an integral part of the process to separate human excreta from human contact. Handwashing after defecation may be more important than handwashing before food preparation and eating because it controls the spread of faecal pathogens in the environment (Curtis 2000). It is, however, a hygiene behaviour rather than contributing towards access to sanitation indicator. Including handwashing as 'condition *sine qua non*' for sanitation would make the value more an indicator for proper use of sanitation facility in terms of hygiene practice, and less of an indicator of presence of appropriate hardware to dispose of human excreta. It was suggested that handwashing should be excluded from the *access to sanitation indicator* for the *WaSH* survey. Handwashing was however included in the survey under the hygiene behaviour indicator described later in this chapter.

Distance to the latrine.

Access and convenience are much more difficult to define than distance or time. One aspect of access is the time it takes to get to the latrine. It transpires that the less time this requires, the more convenient it is to use such facilities. But there is no objective basis available to help indicate an acceptable cut-off point, beyond which non-access can be defined. A factor that might be more important than the distance to the facility is whether the latrine is within the household's compound (i.e. on the property). However if only private facilities are considered improved, the question of the distance can be omitted. Therefore, distances to sanitation will not be considered in our field trials.

Proof of use by all household members

The availability of facilities does not always translate into use (ESL 1996). Proof of use of the toilet is probably the most powerful access indicator possible. Regular use of a sanitation facility indicates that the toilet most likely:

- is socially acceptable (or at least tolerated) by its users;
- provides the safety required when it is used;
- offers the comfort needed;
- can be run at an acceptable cost.

Use of facilities does not mean that access to facilities is convenient or cannot be improved. It is also difficult to ascertain if the whole household (women, children babies mother-in-law's, etc.) use the toilet and do so on all occasions. Signs of use of a latrine are difficult to assess. However, signs, such as not having the key of the cubicle available or overgrowth or other obstacles to the toilet, could indicate that the facility is not in regular use. They are also in line with the exclusion criteria as discussed in Chapter 2. Assessing signs indicating that regular use of the facility is unlikely will be included in the observations used in the survey.

Flies and other vectors.

There are different types of flies that can be found at the household. Musca Sorbens is a possible indicator for the presence of scatter faeces or the lack of containment of human excreta.

Species	Description	Breeding sites	Habits	Density	Importance
Musca Domestic (Housefly)	6-7mm. Grey with 4 dark stripes on dorsal thorax	Animal manure and domestic garbage	Lands on faeces, food and people	Most common species. Often one or two fly season per year.	Most important species. Transmits diarrhoeal diseases particular shigellosis
Musca Sorbens	6 mm. Grey with 2 dark stripes on dorsal thorax	Scattered human faeces (not in latrines)	Lands on people's faces and feeds on eye secretion	Often low density but may be high density where no sanitation programme exist	Implicated in transmission of trachoma
Chysomya Putoria & Chrysomya Megacephala (Blowfly)	10 mm. blue-green shiny appearances	Pit latrines, rotting meat and fish	Lands on faeces and market produce (fish/meat)	Less common than housefly except where extensive breeding in latrines is taking part	May transmit diarrhoeal diseases in market places. May reduce latrine use when breeding in large numbers in latrine pits.

(Simpson-Herbert 1997)

Table 4.22: Various species of flies, description and behaviour

As flies are not contained to particular households their abundance might not be representative of individual households. Differentiating Musca Sorbens and the more common house fly requires proper training of the surveyors. Abundance of flies is seasonal and their activity can change as a result of meteorological conditions and micro climates. For those reason the presence of flies and other vectors is unlikely to be suitable indicator relating to 'improved' sanitation.

Children's sanitation

Indiscriminate defecation in the domestic domain has been associated with an increased incidence of diarrhoea (Han 1990; Stanton 1987a). In a study in Nicaragua Gorter et al. (1991) the presence of a latrine has a beneficial effect on the prevalence of diarrhoea while Mertens et al. (1992) noticed in Sri Lanka study that availability of a latrine is not enough to prevent diseases, but use had to be associated with the availability of a latrine to obtain a safe stool disposal behaviour. Children in rural areas in Nicaragua, less than five years old, infrequently use a latrine because they are afraid of the 'black hole', while mothers regard their faeces as benign (Gorter 1998). Often children defecate in the open and their excreta is cleaned up by the carer and ideally disposed of in a suitable toilet. The disposal of children's faeces is in the *WaSH* survey not seen so much as a factor determining access to sanitation but more as a hygiene behaviour. It will for that reason be discussed as contributing to a hygiene behaviour factor.

Sustainability

There are different aspects to sustainability. As discussed in Chapter 2 the *WaSH* survey methodology defines it as:

> **Sustainable access:** Reliable access that can be maintained for long periods of time

The design of toilets is an important aspect of sustainability. Some design options require regular maintenance while others require periodic replacement such as filled pit latrines. A study in Ghana evaluating a project, which subsidised the construction of pit latrines, showed that few households were inclined to replace their existing facilities (Table 4.23).

What will you do when the pit is full? (n=118)

50%	Will report it to the organisation that provide them the latrine
28%	Don't know what to do
14%	Dig another pit and either transfer or build a new slab.
8%	Go back to using the bush
100%	(Dumakor 2005)

Table 4.23: Action planed after pit latrine is full in a Ghanaian project

When the lifetime of the larine came to an early end through, for example a collapsed pit, more than half would build a new pit (Table 2.24).

In regards to a question regarding future plans when the pit collapses. (n=118)

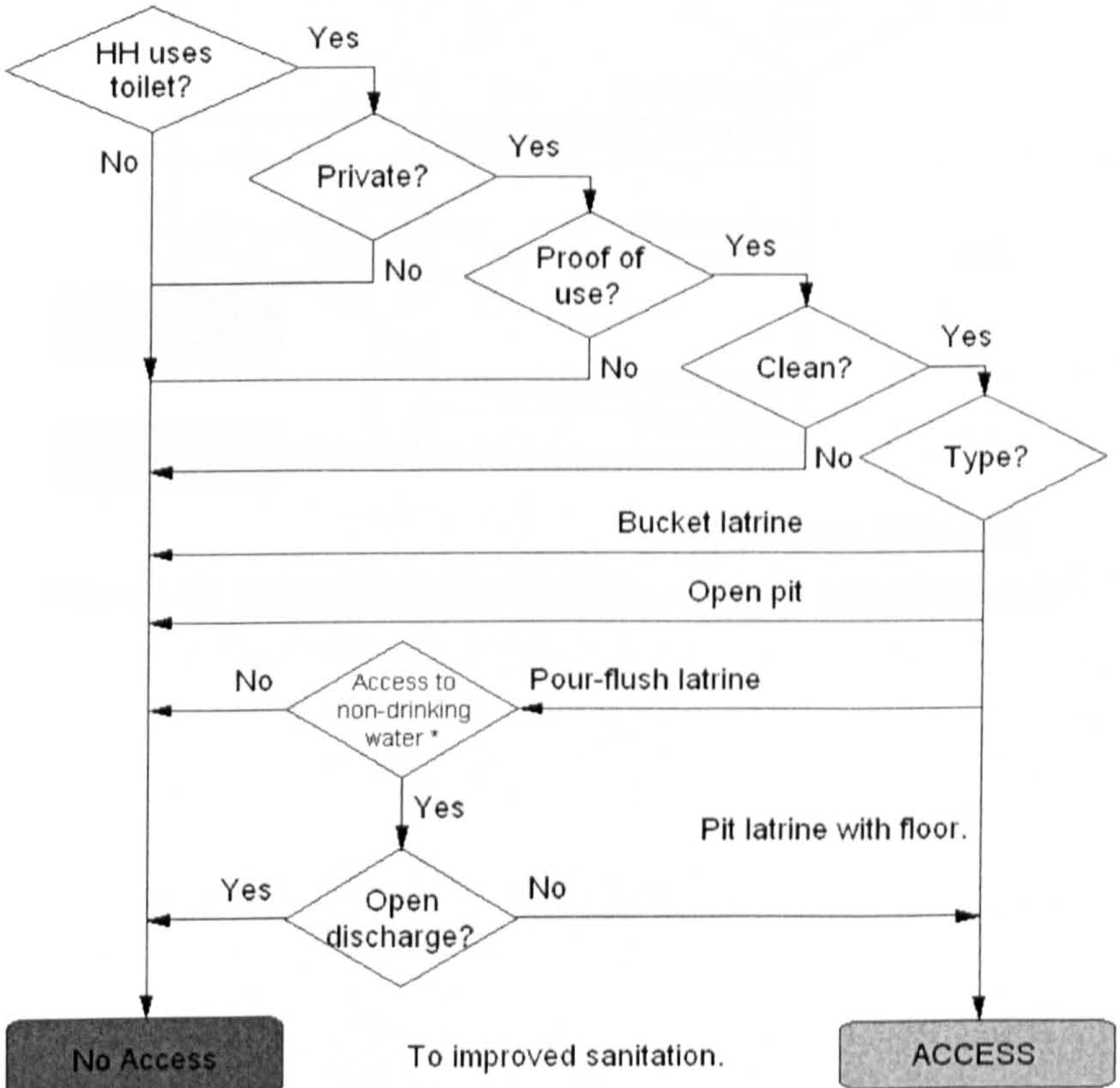
68%	Would build another
23%	Will report it to the organisation that provide them the latrine
7%	Don't know what to do
2%	Go back to the bush
100%	(Dumakor 2005)

Table 4.24: Actions considered when pit of latrine would collapse in a Ghanaian project

In the same study 100% of the interviewers stated that they would rebuild a collapsed superstructure. Information related to sustainability of sanitation facility at the household level, can only be collected from private and some of the shared facilities. It results in qualitative data rather than the clear summative outcome required for the *WaSH* methodology and therefore, it will not be considered in the survey.

4.3.2 Defining the WaSH sanitation indicator

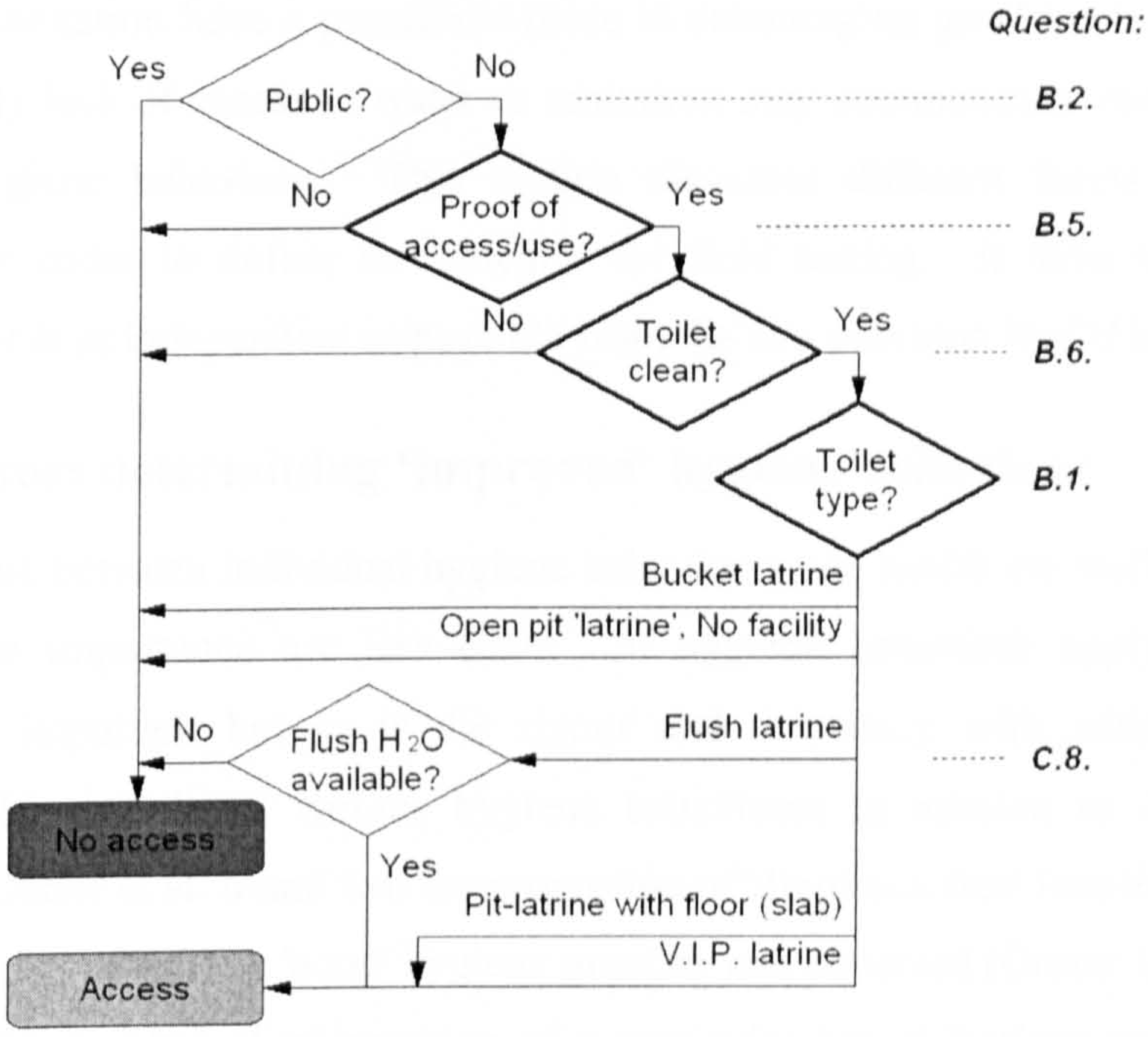
On the basis of the factors discussed, an initial sanitation indicator was defined with as goal to measure *access to an 'improved' sanitation source* as defined for the *WaSH* survey in paragraph 4.3 on page 126. Figure 4.10 shows the initial decision tree as submitted to the WSSCC monitoring task force 18 June 2002 (see documents in Annex A.1). The major change on the basis of the task force's comments and feedback on the suggested sanitation indicator were related to the last question in Figure 4.10 which discarded sanitation with a clear open discharge in surface waters or open canals.



* information available as part of water indicator.

Figure 4.10 Initial decision tree for the sanitation indicator (Bostoen 2002b, p.11)

The adapted decision model for the indicator used in the first field trials is shown in Figure 4.12. As with the water indicator, Annex B.1 contains the first version of the survey questionnaire rationale, conclusion assumption and remarks for each question while Annex B.2 contains only the questionnaire. Annex B.3 contains the arguments for the indicator which has been partially discussed above. Changes to the questionnaire following peer review can be found in Annex C which also contains the questions referred to in Figure 4.12. The questionnaire in Annex C not only contains conclusions, rationale assumptions and remarks, but also details of where the question originates from.



(Bostoen 2002a,p.32)

Figure 4.12: Decision model for sanitation as used in initial field trials

4.4 Determining 'improved' hygiene behaviour

The *WaSH* hygiene behaviour indicator is the last of the three *WaSH* indicators. Human behaviour in this context can be defined as *the way people act in general in regards to hygiene* (Boot 1993,p.134). Hygiene, derived from the Greek *hygieinos*, meaning healthful, is used in this thesis as the "*...practice of keeping oneself and one's surrounding clean, especially in order to prevent illness or the spread of disease*" (Boot 1993,p.6). WHO (1992) considers faecal-oral transmission as the biggest cause of hygiene -related morbidity and mortality which is largely preventable through access to water, adequate sanitation and hygiene practices (Cairncross 2006). Water and sanitation have a prominent place in encouraging good hygiene practices. Consequently lack of access to water or sanitation may automatically result in a lack of good hygiene behaviour. This section discusses different facets of hygiene behaviour in order to define an indicator for field testing. It aims to define an indicator that is as independent as possible from the two previous *WaSH* indicators.

4.4.1 Factors determining 'improved' hygiene behaviour

While the link between individual hygiene behaviours and health are well understood their relative importance are less clear. In hygiene behaviour applying certain practices is important but so is the rigour and frequency with which they are practiced. In a study of various hygiene behaviours in relation to diarrhoea in Nicaragua, Gorter et al. found that the proportion of 'diarrhoea free' families increased with the number of times a 'good' hygiene practice was observed (Gorter 1998). They considered the number of observation of a particular '*good hygiene practice*' in a household was a strong indicator for the importance of that specific hygiene practice in the transmission of diarrhoea. However, directly measuring the frequency of such behaviour in the *WaSH* survey will be impossible due to the short contact time with the interviewees.

Boot and Cairncross (1993) distinguishes five different domains of hygiene behaviour as shown in Table 4.25.

The first two domains ① human excreta disposal and ② use and protection of water sources are related to Target 10 of the MDG and have been covered earlier in this chapter.

- Disposal of human faeces;
- Use and protection of water sources;
- Personal hygiene
- Food and water hygiene*
- Domestic and environmental hygiene

(Boot 1993,p.35)

Table 4.25: Different domains of hygiene behaviour

The three other domains ③ personal hygiene, ④ food hygiene and ⑤ domestic and environmental hygiene will be used below to categorise the different sources of information that could contribute to an indicator which aims to assess hygiene practices.

Personal hygiene

Personal hygiene, the first of the three hygiene practices listed in Table 4.25, is discussed in this section. It covers handwashing, disposal of child faeces, cleanliness of sanitary facilities, location of toys and baby bottles.

Handwashing

Worldwide, handwashing is one of the few practices that has been universally promoted by people of various religions and cultures throughout the ages (Hoque 2003). It has a clear impact on health, as shown in Table 4.26, which contains a non-exhaustive list of studies illustrating the association between handwashing and health (in this case, diarrhoeal and respiratory infections).

* Food hygiene is the term most frequently used in the water and sanitation sector, though specialists more often refer to it as food safety (Boot and Cairncross 1993).

Intervention	Outcome (...% reduction in ...)	Reference
Handwashing (HW) promotion	14% ... incidence in diarrhoeal disease (DD) in children <6 years	(Torun 1982)
Handwashing promotion	84% ... secondary attack rate of *Shigellosis*	(Khan 1982)
Controlled HW after contamination with enteric pathogens	50 to 100% ... enteric pathogen counts for diarrhoeal diseases	(Feachem 1984)
Handwashing promotion	26% incidence reduction in DD	(Stanton 1987a)
Handwashing promotion	30% ... incidence of DD in children	(Han 1989)
Handwashing promotion	62% incidence reduction in DD	(Shahid 1996)
Handwashing promotion	39% incidence reduction in DD	(Pinfold 1996)
Handwashing promotion	45% ... incidence of respiratory infection among naval recruits	(Ryan 2001)
Systematic review on HW with soap	42% ... risk in diarrhoeal diseases	(Curtis 2003b)
Hygiene promotion	36% ... in diarrhoeal morbidity	(Cairncross 2006)

Table 4.26: Effect of handwashing on diarrhoeal diseases and respiratory infections

Handwashing is an important personal hygiene practice and a useful indicator for personal hygiene behaviour (Curtis 2003b; Luby 2005; Luby 2004), however the prevalence of handwashing in a household is more difficult to assess (Curtis 1993; Pinfold 1996; Ruel 2002).

Defining handwashing

Just defining what is understood by handwashing proves challenging. This is demonstrated by Zeitlyn (1994,p.51) who observed handwashing in a Bangladeshi village. An individual might "*rub the left hand with mud and rinse it with water after defecation, or pour water over the right hand before eating, or rub hands and , arms legs and feet with water before prayer, or wash hands along with other parts of the body with soap in the course of a daily bath*". All of these actions might or might not be classified as handwashing. For example the wetting of the right hand before a meal is often more to prevent food sticking to the hand during the meal, than about cleaning hands (Kamanda 2002). Activities such as washing cloths are very effective in removing faecal contamination from hands (Hoque 1991) but might not be classified as handwashing (Zeitlyn 1994).

All aspects of handwashing are not fully understood (Hoque 1995; Kaltenthaler 1991). Important aspects for the removal of pathogens from hands are:

- the amount of time and vigour expended washing (Hoque 1995; Price 1938);
- the use of a cleansing agent such as soap, sand, ash (Curtis 2003b; Esrey 1985; Esrey 1991; Hoque 1995; Price 1938);
- amount of water used for rinsing (Hoque 1995);
- drying of hands after rinsing (Hoque 1995).

In the *WaSH* survey, handwashing is defined as:

• rubbing both hands against each other;
• using soap or another cleaning agent while rubbing hands together;
• rubbing hands together while rinsing hands together.

Table 4.27: *WaSH* definition of handwashing

Assessing handwashing behaviour in surveys such as DHS is notoriously difficult (Kleinau 2002). An initial question "*when do you wash your hands*" (without prompting) was put forward but proved unsatisfactory (Kleinau 2002). Asking about appropriate times for handwashing during a pre-test in the Dominican Republic, two out of three answers were eliminated because they had no discriminatory power. There, the handwashing question was reduced to: "*The last time you prepared a meal for your family, before starting did you wash your hands?*" (Kleinau 2002; ORC Macro 1995). Because most people (>90%) respond positively to this remaining question, its usefulness is questionable. Clear over-reporting on handwashing behaviour compared to its occurrence in structured observations is common (Manun'Ebo 1997; Shordt 2001). This raises the issue of how to gather information on handwashing when it cannot be done in a meaningful way through a single question.

Different studies have tried with little success to find the right non-leading single question to assess handwashing. E.g.:

- On which occasions do wash your hands?
- On what occasion do you teach your children to wash their hands? (sic)
- Do you use soap when you wash hands?
- On what occasion do you use soap to wash your hands?

(Kleinau 2002; Pearson 2004)

These attempts have had so far limited success. Some might over-report handwashing activities while being a habit forming activity it can be underestimated by others. Another possible reason is that our etic view of washing hands for hygiene purpose does not correspond with people's emic view of what constitutes handwashing. It could be that people wash their hands mostly for purposes other than hygiene (Zeitlyn 1994).

Some research showed that not only is the purpose of handwashing varied but compliance changed during the day (Huttly 1994). Also few studies make any distinction between handwashing as a primary and a secondary barrier (Curtis 2000,p.55). First barrier handwashing, after defecation, keeps pathogens out of the human environment while second barrier handwashing keeps pathogens in the environment from directly or indirectly entering a new host, as shown in Figure 4.12.

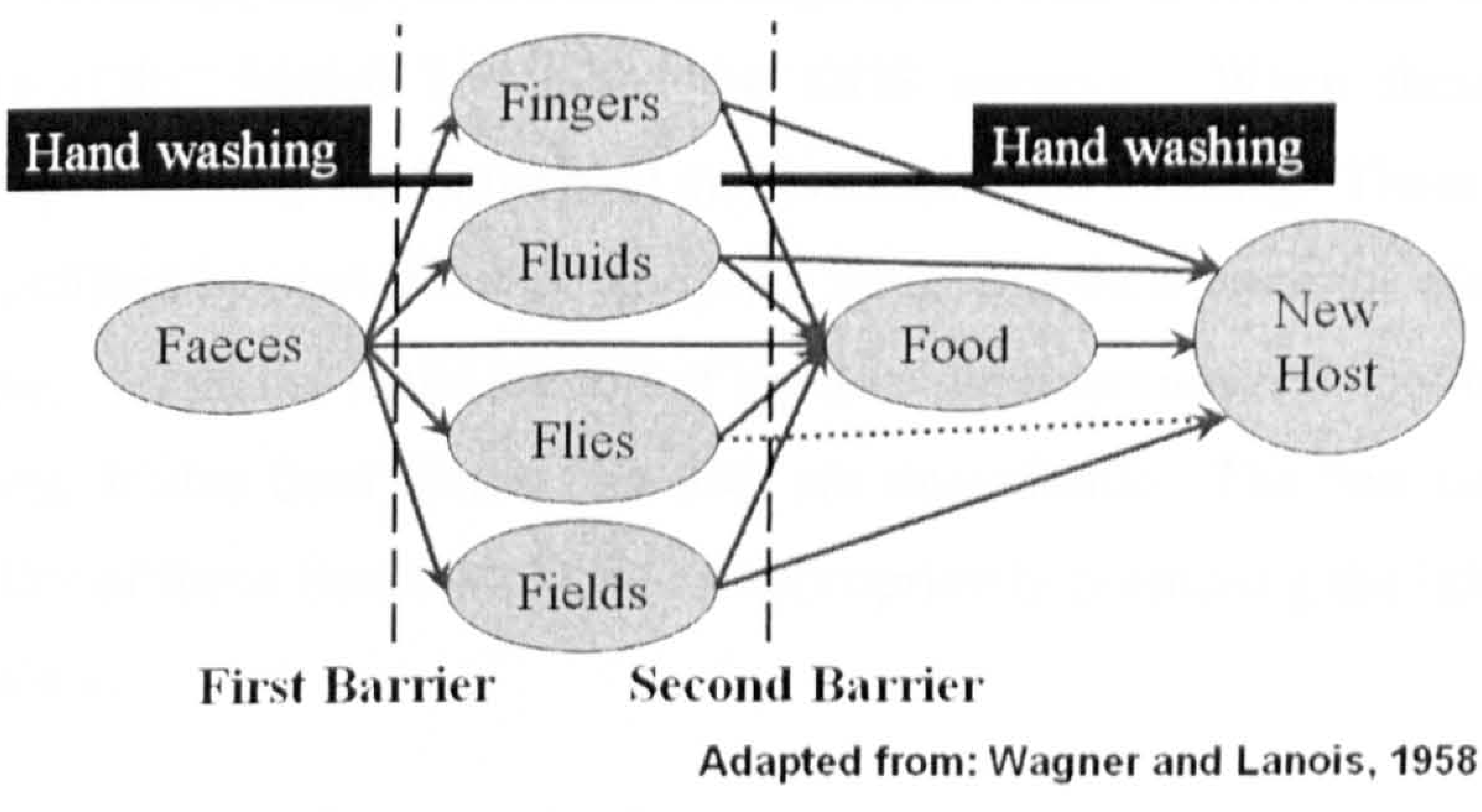


Figure 4.12: F-diagram including first and second barrier handwashing

Until now hygiene behaviours such as handwashing have been most reliably assessed in long (un)structured and repeated observations (Cousens 1996; Curtis 1998; Curtis 1993; Gorter 1998), but these require time, skills and other resources not available to the *WaSH* survey method. It is clear that there is a need for additional research to determine the best way of assessing hygiene behaviours like handwashing (Hoque 1995; Kaltenthaler 1991; Ojajarvi 1980).

Questions surrounding handwashing are too unreliable to be considered in the *WaSH* survey. The probability of directly observing handwashing in the household will vary during the day and it is unlikely to be observed often during the short contact time the interviewer has at the household. For this reason questions on handwashing behaviour or direct observation of handwashing should avoided where possible. Other forms of assessing handwashing will be considered below.

Dedicated place for handwashing

Handwashing is more frequent if handwashing facilities such as soap and water are easily available in locations close to the contaminating point (Curtis 2003a). Field trials could assess whether households with a dedicated place for handwashing are more likely to practise handwashing in contrast with households who do not. The criteria that define such a place are essential to such an assessment. Handwashing, as defined in Table 4.27, requires that both hands are put and rubbed together during washing and rinsing. To allow each individual to rinse hands whilst rubbing requires the availability of items such as a tap, basin, bucket, sink or tippy-tap. It requires the availability of a cleansing agent as well as enough water for rinsing. Assessing the presence of water/tap, soap and a basin through spot-observations is also suggested by ORC Macro (ORC Macro 1995) for the DHS surveys. When these items are unavailable it is unlikely the household can practice handwashing. These objects can be easily identified by spot-observation (Ruel 2002) but their presence alone does not guarantee use. When the items are out of sight of the interviewer or not together in a dedicated area, it also does means that they are unavailable. The best way to assess the availability of these items might be by appropriately prompting the interviewee as discussed below.

Handwashing demonstration as an indicator

Instead of spotting handwashing items during the interview, the interviewer can ask the interviewee to demonstrate her (his) handwashing technique. This prompt allows not only to see if the required items are available but also if the interviewee uses them appropriately.

Demonstration could be evaluated as follows:

- can get all things needed (e.g. water, washing agent, basin when needed) within one minute.
- uses soap or any other washing agent, like ash or sand.
- uses both hands,
- rubs hands rigorously during soaping and rinsing,
- no prompting by other people.

It is assumed that households which fail to demonstrate as outlined above are unlikely to be regular handwashers as defined in Table 4.27.

Some studies showed that knowledge of handwashing practices are more prevalent than are successfully demonstrationed (Shordt 2001). This follows the general trend highlighted in many publications that hygiene practices are much better known than practised (Curtis 1993; Gorter 1998; Manun'Ebo 1997). A study in Kerala showed that women participating in the study were more likely to use a correct washing technique compared to children or men taking part in the study. This might indicate that in this respect the women are not as representative for the whole household as assumed in Chapter 2.

Demonstrations are likely to take more time than spot-observations or questions. This is the main reason why the DHS survey does not consider handwashing demonstrations (Kleinau 2002) and why the WSSCC task force on monitoring requested not to pursue demonstrations as a way of data collection in the *WaSH* survey. As discussed in Chapter 9 however, it might have been a mistake excluding demonstrations from the *WaSH* survey as they allow for clear and standardised observations.

Pocket-voting

Pocket-voting, as explained in Chapter 2, could be used to determine how prevalent the reported handwashing actually is. This approach assumes that interviewees know their behaviour and are willing to communicate that to the interviewer given the possibility to do this surreptitiously. Pocket voting – asking for key moments when handwashing is practiced – was used in the in *WaSH* survey.

Bacteria on fingertips

Hands are a major cause for the transmission of pathogens. Direct measurements of the presence of indicator organisms on hands have met with various levels of success (Kaltenthaler 1988; Kaltenthaler 1991; Ojajarvi 1980; Pinfold 1990; Pinfold 1996; Pinfold 1988). Although this could become a suitable source of information, it requires equipment and technical skills which makes it unsuitable for the *WaSH* survey. While not considered for the field trials, some work has been done during this research to further develop the collection of this data, as will be discussed in Chapter 9.

Proper disposal of children's faeces

Although strictly excreta disposal, in the *WaSH* survey the collection and disposal of small children's faeces was considered to be a behaviour because this has to be done by an older person. This question has been considered in the DHS core questionnaire (Kleinau 2002) and was added to UNICEF's MICS survey (Henderson 2002). However, data analyses by UNICEF suggested this question was not useful as a stand alone question (Henderson 2002).

According to Curtis et.al. (Curtis 1993), a good (and non-leading) question to collect data could be "*What happened the last time your child defecated?*" Possible answers could be categorised as follows :

- leave on the ground.
- throw outside the yard.
- throw in the toilet/latrine.
- throw in the river/stream/pond.
- bury in the yard.

When there is no access to sanitation, this will result in a negative value for the hygiene indicator for this aspect. This is because throwing in the toilet is the only suitable way of hygienically separating children faeces from human contact (Table 4.16). For households with no young children this question will result in no data. Still it was consider worthwhile including it in the draft questionnaire.

Uses of diapers, clean underclothes and cleaning small children's bottoms

In a review of seven studies using spot-observation (Ruel 2002), the absence of diapers, and unclean underclothes and child's bottom were identified as a good indicator for child diarrhoea. While this might contribute to a suitable indicator for hygiene behaviour, the same publication noted that use of diapers could be associated with living standards and income of the households. It therefore does not seem to be a suitable indicator and will for that reason not be considered.

Cleanliness of sanitation facilities

While cleanliness of sanitation facilities could be an indicator for hygiene practice evidence of this could be found in literature. It can only assessed in households which have access to sanitation facilities and this makes this aspect of a possible hygiene indicator partially dependent on access to improved sanitation. Moreover it is already included in the *WaSH* sanitation indicator and will not be used as an indicator for hygiene practices.

Food and water hygiene

This is the second of the three hygiene domains mentioned in Table 4.25 on page 143. Faecal pathogens are likely to be higher in food than in water because food, contrary to water, provides a substrate on which they can proliferate (Boot 1993; Cairncross 1995). As with water quality, assessing food hygiene require skills and equipment which are beyond those planned for the *WaSH* survey methodology. Observational data, which could be a suitable proxy, are difficult to collect when the contact time with the interviewee is kept to a minimum. For that reason food hygiene will not be considered as an aspect contributing to a *WaSH* hygiene indicator.

Water consumption

As discussed on page 102, increases in water consumption and 'improved' hygiene have been linked to improved hygiene behaviour (Cairncross 1987). It is neither an unambiguous nor easy indicator to collect and was not considered for the *WaSH* field trials

Water storage

In a WHO study (1992,p.16) covered and un-covered drinking water storage was among the two most significant hygiene behaviour identified. Covered water storage has also been used in other publications as an indicator for hygiene behaviour. However, the WSSCC taskforce on monitoring considered this aspect of limited value and preferred the aspect below on a suitable drawing mechanism for drinking water.

Suitable water drawing mechanism for drinking water

'Suitable' is defined here as: 'a method preventing the user from polluting the water by consuming it'. This can be evaluated by examining the way people draw drinking water. If a method is used that enables the user to draw water without using their hands or bringing a potentially 'polluted' container into contact with the water, this will be achieved. A tap, or a dedicated ladle, which is not stored on the ground, could are examples of suitable solutions. The assumption is that a lot of pollution happens at the household level if the water has to be stored in the household. Although the household will have to demonstrate to the interviewer how they draw their drinking water, it might be a suitable aspect to the indicator and will be included in the trials.

Storage conditions of food

The presence of leftover food and covering food after cooking to protect it from flies have been used in some research as an indicator. Relationships have been found between health and how prepared and unprepared food is stored (Molbak 1989). However such an indicator could only be useful between the time the food is cooked and leftovers are eaten. The small timeframe in which this might be observed makes this indicator less useful to the questionnaire, and therefore it will not be used.

Cleanliness of dishes and utensils

Although this seems at first to be a good indicator, it is not always easy to evaluate. First of all there is the problem of privacy. Dishes and utensils will often be in the cooking part of the household, which is not easily accessible to the interviewer to make observations. Moreover the inspection can only be done visually which makes it dependent on the type of food eaten. The way dishes are stored could be considered but even if they are stored on the ground they might be rinsed before use. If this indicator were assessed just after a meal, it would be difficult to make a correct assessment and as such is seems not a reliable contribution to a hygiene behaviour indicator.

Domestic and environmental hygiene

This is the last of the three different hygiene domains considered by Boot et al. (1993,p.35) listed in Table 4.25. It considers waste disposal, cleanliness of floors, compounds and animal roaming around the living area.

Waste disposal

Domestic solid waste in developing countries usually contains a degree of faecal contamination. While solid waste and health are related (Heller 2005; Rego 2005) direct evidence that solid waste disposal has an impact on the disease burden is sparse (Heller 1999; Parkinson 2003; Prado 2003). Waste disposal is not entirely under the control of the household. In areas where few possibilities are available to dispose of solid waste, such as in urban and peri-urban areas, waste will have to be collected and transported away from the conurbation. The willingness to store households waste at the household prior to collection will depend highly on the availability of such a service. As such the waste disposal behaviour will depend strongly on the public services available. Therefore, this behaviour is less suitable as an indicator characterising the hygiene behaviour of the household, which is in the domestic domain. For that reason, waste disposal will not be considered as an indicator.

Cleanliness of floor and compound surfaces

The problem with floor assessments is that it is not always possible to have access to the house. This is not important if we evaluate both compound and floor. If either show no signs of cleanliness (e.g. garbage not organised in heaps or absent or, worse, there are faeces of any origins visible) the indicator will be negative.

If the compound the household is using is shared and there is no clear ownership of a relevant part of the compound, it will be evaluated as a whole. This reflects the behaviour of the whole compound community rather than the household. In reality it is more likely that despite the effort of some individuals the compound will not remain clean. If there are children in the household, particular attention should be focused on where children play. Another issue, is that cleanliness is still too vague as a description to be a useful indicator. The following indicator proves to be more constructive and as a result, general cleanliness of floor and compound surfaces will not be considered as an indicator.

Area in and around the household free of children (human) and animal faeces

While the absence of children (human) and animal faeces is an often-used parameter, it is sometimes difficult to distinguish between the two. Therefore, both are considered. This means that even households without children can be marked on this indicator. The problem is that it is focused more towards low income housing in tropical climates. As this is a relatively subjective observation, interviewers have to be well trained to make these observations, and to make them as standardised as possible. But this indicator is considered a useful one for the *WaSH* field trials.

Animals loose inside the house or the compound.

There are many open questions and much conflicting information about the role of animals in the transmission of water and sanitation related diseases (Boot 1993). There are studies showing a correlation between keeping animals in the house and increased risk of diarrhoea (Molbak 1994; Molbak 1997; Pickering 1986; Westaway 2000), although some studies surprisingly found that animals in the house was associated with lower diarrhoea rates (Huttly et al. 1987 in Boot (Boot 1993). The WSSCC taskforce on monitoring agreed that this would not be a suitable indicator for the *WaSH* methodology.

4.4.2 Defining the WaSH hygiene behaviour indicator

On the basis of the information above an initial water indicator was defined with as goal to measure *practice of 'improved' hygiene behaviours*. The five different aspects of hygiene behaviour on which information is collected (Annex C) do not relate to their indicator as do the decision models for other indictors (Figure 4.8 page 126 or Figure 4.12 page 141). Although some of the measured aspects related to hygiene behaviour there is no objective basis to use any weighting for the different answers. This led to using Table 4.28 as an alternative decision model.

A = No. of outcomes which were positive	*Q = No. of outcome obtained in the HH survey*				
	1	2	3	4	5
1	**X**	**X**	N (33%)	N (25%)	N (20%)
2	**X**	**X**	Y (67%)	N (50%)	N (40%)
3	**X**	**X**	Y (100%)	Y (75%)	N (60%)
4				Y (100%)	Y (80%)
5					Y (100%)

X results in non-response
Y/N means does/doesn't apply hygiene practices.
(%) 'percentage of good practices'.

Light shading: Good Hygiene Practice.
Dark shading: No Good hygiene practice

Table 4.28 Decision model for 'improved' hygiene practices

If for example there are four outcomes (one non-response) of which only three outcomes were positive in relation to hygiene practices this would result in three out of four (75%) good practices which is > 2/3 (66%) which means the household is considered to comply with good health practices, hence the green colour in the table.

A= No. of outcomes which were positive	*Q=No. of outcome obtained in the HH survey.* 1	2	3	4	5
1	**X**	**X**	N (33%)	N (25%)	N (20%)
2	**X**	**X**	Y (67%)	N (50%)	N (40%)
3	**X**	**X**	Y (100%)	Y (75%)	N (60%)
4				Y (100%)	Y (80%)
5					Y (100%)

X results in non-response
Y/N means does/doesn't apply hygiene practices.
(%) 'percentage of good practices'.

Good Hygiene Practice.
No Good hygiene practice

Table 4.1: Use of the decision model for 'improved' hygiene practices

The 2/3 cut-off point is an arbitrary value which should be validated. It acknowledges that the household that could be classified as having 'improved' hygiene behaviour will not show that behaviour all the time. Not taking this in account would result in very low prevalence. If 50% of the households practice 66% of the time an 'improved' hygiene behaviour this would otherwise result in 33% of prevalence (50% x 66%) instead of the 50%. Although this was the original decision model for the hygiene behaviour indicators, all the arbitrary cut-off points could not be validated and the model was abandoned as explained in Chapter 9.

4.5 Validating the indicators

In the previous sections this thesis has attempted to formulate compounded proxy indicators that accurately express the critical aspects of each of the *WaSH* indicators. This section describes how the accuracy of these proxy indicators will be tested. But This validation process is not without its problems as is discussed below.

4.5.1 Objectives of the validation

The values for each of the three *WaSH* indicators are obtained by compounding data obtained by means of questionnaires, spot-observations and pocket voting which serve as practical surrogates for the direct measurement of the performance of interest. The assumption that these indicators above represent reality has to be tested during the field trials. This can be done by verifying if the indicators lead to a similar result that is obtained by a recognised 'gold' standard (validity) and that they lead each time to the same result (reliability).

One of the major problems, particular for the hygiene behaviour indicator, is that there is no 'gold standard' against which validity can be assessed (Manun'Ebo 1997). Validation is therefore limited to assessing how valid and reliable *WaSH* data are in comparison with the most accurate method known in collecting such information.
Generally direct observation is considered the most reliable way of collecting water, sanitation and hygiene behaviour data (Curtis 1998). Therefore, different additional methods of data collecting (Table 4.30) will be used to triangulate and validate the *WaSH* data collected.

(Hygiene practice, Access to improved water sources and access to sanitation)

Type of test► ▼Objective	Environ-l walk	Structured observation (spotcheck).	Pocket charts	Foc. group discussion subsample.	Foc. group discussion population	Key-informant interviews.	Community mapping	Seasonal calendar	Goal of the test	Reliability	Validity	Blind test
Etic 'validation' household level		X	X						Evaluate if the core questions, observations and assumptions are valid	X	X	Y
Etic 'validation' of cluster 'results' of each indicator.	X					X			Evaluate if the results are representative for the targeted population from surveyors perspective.		X	Y
Emic 'validation' of individual interviewing process.				X		X			Appraisal of methods and tools and their relation to trustworthy information.		X	-
Emic 'validation' of cluster 'results' of each indicator.				X			X	X	Evaluate if the results might be representative for the targeted population from their perspective.		X	Y
					X	X			Proclamations of preliminary results from survey and assess population's opinion on them.		X	N
Checking interviewer's bias									Spot-observations	X		

Table 4.30: Alternative data collection to validate and triangulate data collected I the *WaSH* survey trials

To avoid bias in the validation process by surveyors eager to authenticate the *WaSH* data, the validation process has to be as blind as possible (Figure 4.1). Validity and reliability can be measured at the BSU level (Figure 4.1) as well as population level. While validation at BSU level would be the most rigorous validation, it is less likely to be achieved. If for example 50% of the households practice 66% of the time an 'improved' hygiene behaviour the prevalence of hygiene behaviour at any given time would be 33% (50% x 66%) but it would not be the same households all the time that constitute this 33%. In the field trials, validation will aim to validate the reliability and repeatability of the WaSH indicator at the BSU and population level.

All the questions and observations used for the indicators are in the private domain and interviewees as well as interviewers might feel uncomfortable with the process. It is still essential to get the right selection and training for interviewers (Kendall 1994) Moreover water, sanitation and particularly hygiene practices are private issues and morally loaded. Not everybody is willing to admit to not washing their hands, for example. When selecting ways of validating the survey questionnaire we have to make sure that we use methods that are representing reality. If our validation methods result in similar biases as the survey, we might seem to be validating outcomes, because both results are in alignment; but they might not be representative of the real value!

4.5.2 Methods to validate the *WaSH* indicators

Table 4.30 lists methods of collecting information that can be used for validation of the survey data. The survey is a snapshot of selected information that can be collected in ways that are more thorough. If, for the purpose of validation, this information is collected in a subset of the survey sample by a more thorough method, the outcomes obtained could be compared as shown in Figure 4.1. Structured observations of a randomly selected sub set of household will be used to compare the survey data (Figure 4.1). For that purpose open ended questions and non-structured observations are not suitable because they give such a wide variety of answers that it is difficult to score them in such a way that they can lead to a value for each indicator.

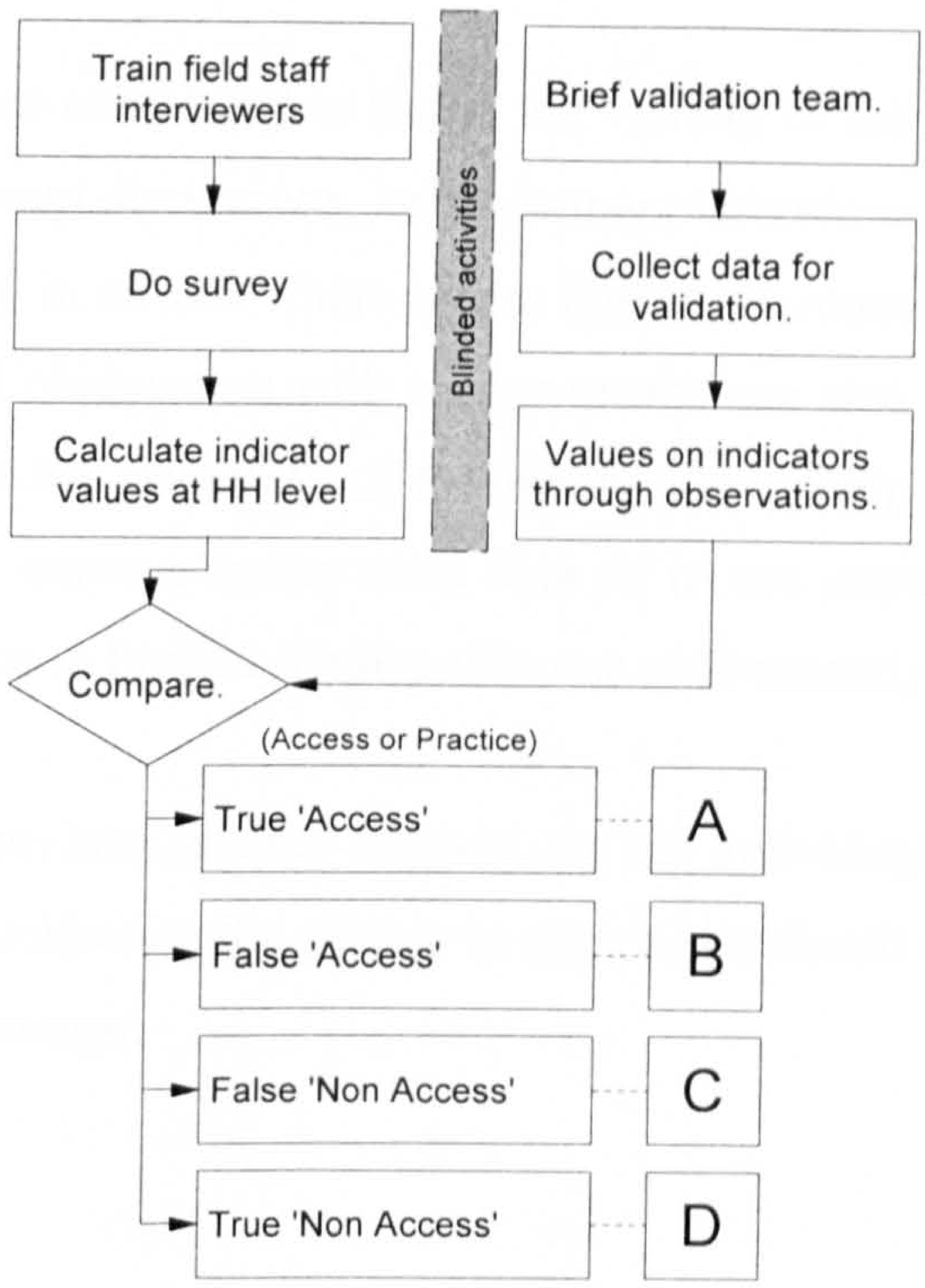


Figure 4.1: Indicator validation protocol

The formulae in Table 4.32 are used to rate screening programs. They are relatively easy to use, when assuming that the validation data forms the "gold standard".

		'Validation' access or practice status	
		Positive	Negative
Survey status	Positive	A	B
	Negative	C	D

Table 4.31: Overview of validation data

$$\text{Sensitivity} = \frac{A}{A+C} \qquad \text{Positive Predictive Value} = \frac{A}{A+B}$$

$$\text{Specificity} = \frac{D}{B+D} \qquad \text{Negative Predictive Value} = \frac{D}{C+D}$$

Table 4.32: Formulae used for validation

Other methods are also considered to assess the validity of the obtained results, such as the use of focus group discussions, key informant interviews, community mapping and holding the survey in an area where access figures are already known.
Comparing structured observation with survey results can also be used as a measure of reliability. To test the reliability of the whole methodology there was an initial plan to hold multiple surveys in the same area or to use extra PSU and do Monte Carlo simulations. Due to limited funding this was unfortunately not feasible.

While this and the previous chapter focused on the individual indicators, the next chapter will focus on collecting the sample in such a way that it can be representative for the population of interest.

CHAPTER 5 HOUSEHOLD SURVEY SAMPLING

5.1 Introduction

The collection of accurate data is the foundation for all scientific data analysis. The results of even the most sophisticated statistical techniques are only valid if the collected data are representative of the population under study. The quality of the data depends on the quality of the sampling process and the measures used in their collection. Chapter 4 looked in detail at which measures could be used to measure adherence to hygiene practices and access to sanitation and water. This chapter will look in more detail at representative samples, while Chapter 6 will cover the practical issues regarding survey sampling.

The first part of this chapter covers basic aspects regarding representative cross sectional sampling. It starts with the basis of all sampling the simple random sample (SRS) in which any basic sampling unit (BSU) has an equal chance of being selected. As SRS is often impractical, this part of the chapter looks to alternatives such as cluster sampling.

In the second part of this chapter, the sample size and the ideal number of clusters are determined. These sample sizes are based on traditional sampling requiring sampling frames, which are not always available or feasible. The third part of this chapter examines alternative sampling strategies when traditional sampling plans are unfeasible. The last part covers precision and bias leading into non-sampling errors covered in Chapter 6 and finishes with a description of the sampling methods selected for field testing the *WaSH* indicators.

5.2 Representative sampling

The aim of the *WaSH* survey methodology developed in this thesis is to obtain coverage figures. This makes the selection of a representative sample an essential part of the methodology. Selecting a sampling method will require following a number of steps, as described below:

- Clearly definition of the **basic sample unit** (in this thesis, the BSU is the household see Chapter 2);

- Clear definition of the **target population** (in statistics also referred to as the reference population or the universe) from which the sample is collected, Survey outcomes cannot and should not be generalised outside the defined target population;
- Determine a **sample strategy** in which each basic sample unit in the population (as defined) has an equal or a known ($\neq 0$) chance of being included in the sample;
- Determine the **maximum error,** relative (ε) or absolute (d) allowed for the outcome. (These are only sampling errors in relation to the precision of the estimated outcome);
- Determine other factors influencing the chosen sampling method, e.g. measurable progress between surveys which has to fall within given confidence interval (CI); the need of comparing subgroups as well as stratification;
- Determine the sample size required for each sample design taking into consideration required confidence intervals.
  If cluster sampling is used, determine the design effect (*deff*), and the rate of homogeneity[1] (ρ);
- For each sample design, estimate the field costs;
- Choose the most convenient design with acceptable field costs.

All these steps will be discussed in the rest of this chapter.

5.3 Basic sampling unit and population

Determining the population to be targeted by a survey requires clear inclusion criteria such as age groups, gender and existing administrative boundaries or geographical locations. The basic sampling unit in this population is the 'individual' whose characteristics we want to measure. A practical BSU for a WASH indicator is 'the household' as discussed before in Chapter 2. This is possible because all the members in the household are likely to use the same water source or toilet when they

[1] In literature the abbreviation 'roh' for rate of homogeneity and 'rho' for de Greek letter 'ρ' are both used to denote the generalised 'intra-cluster correlation coefficient' ICC.

are within this household. So the survey data will be collected in the private or **domestic domain**, and will mainly focus on processes and actions occurring there, although some of the data collected relates to the public domain. The domestic domain means the area normally occupied by and under the control of the household (Cairncross 1996). By excluding data collection in public places or the public domain, the survey does not deny its importance in disease transmission but focuses on the more vulnerable part of the population – children (mainly aged under five years) and the elderly – which carry a large part of the disease morbidity and mortality burden (Agarwal 2003). These vulnerable groups spend most of their time in the private domain.

The domestic domain is also chosen for practical reasons. It is difficult to find a selection methodology for the **public domain** that allows all people to have a known chance of being included in the survey sample. Some of the fieldwork carried out during this research includes parts of public domain, such as schools, but it is only included as far as it relates to household surveys which is the specific scope of this thesis.

For other aspects relating to access, such as 'sustainability of water sources' or 'number of beneficiaries per source' the water source should become the basic sampling unit. Such surveys often using Geographic Information Systems (GIS) have been implemented by various organisations such as WaterAid (Stoupy 2003; Sugden 2003). Those methods are complementary to the household survey discussed here and can help to capture a larger part of a complex reality. The use of households as a BSU can also result in other problems which will be discussed later.

5.3.1 Sample strategy

Sample plan, -design or -strategy refers to the process of determining which BSU are to be included in the sample. It also determines how the data will need to be analysed to obtain valid information. Data without any supporting information on the sample strategy will have little or no use as this chapter will later demonstrate.

Simple Random Sampling

The simple random sample forms the theoretical basis for representative sampling. It gives all BSU an equal chance of being included in the sample. Although SRS is conceptually simple, in household surveys it is often not feasible in practice as it requires identifying and labelling all households prior to sampling. Moreover, in a large-scale universe, individual sample households may be many kilometres apart. Alternative methods such as cluster sampling, as discussed below, proved more practical for household survey.

Cluster Sampling

The most practical and commonly-used alternative to SRS in household surveys is cluster sampling. The simplest form of cluster sampling is the **single-stage** cluster sampling design (Levy 1999). In this sample design the population is divided into smaller contiguous groups often referred to as primary sampling units or PSU. A number of PSU is selected randomly and all the households in the selected PSU are included in the sample as shown in Figure 5.1.

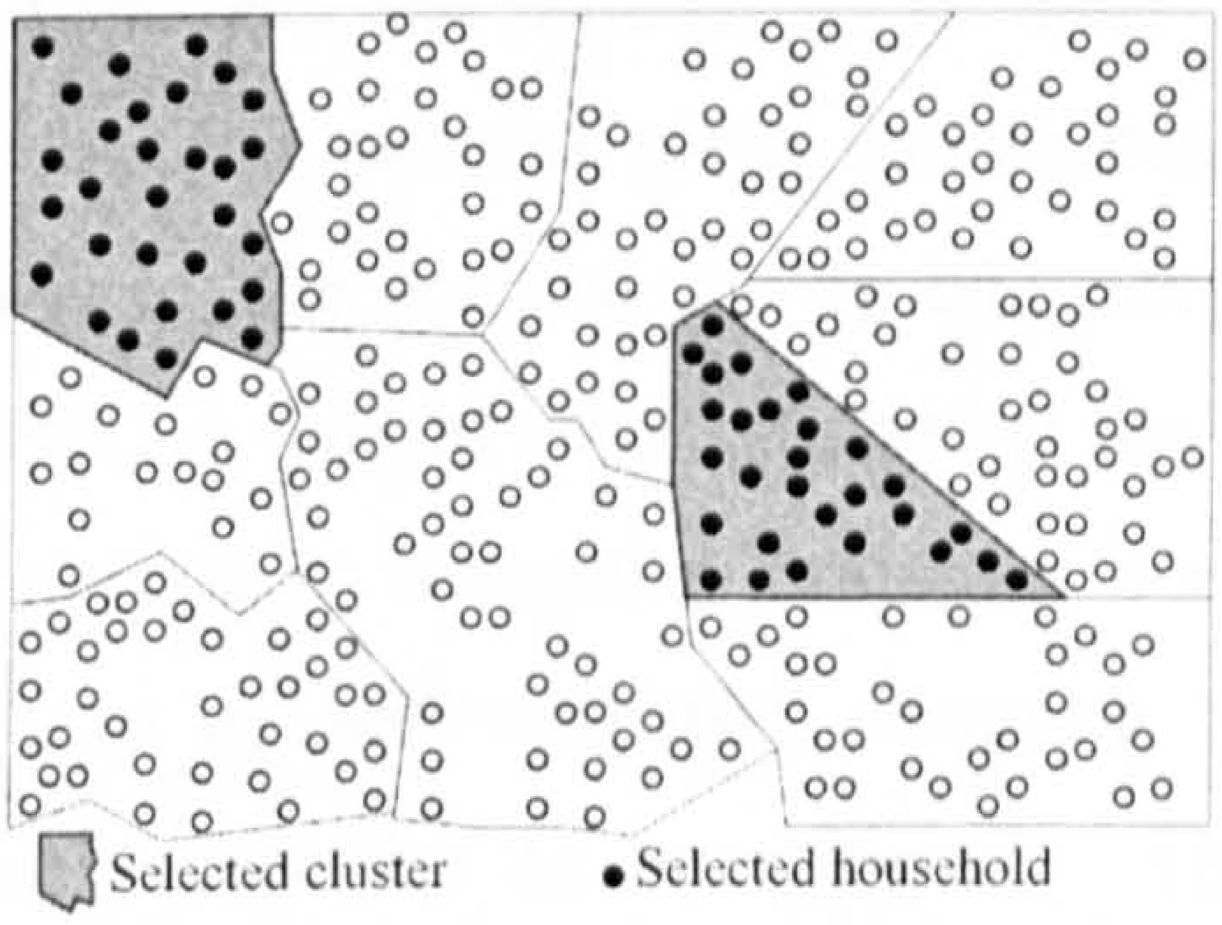


Figure 5.1: Example of single stage sampling

This method is relatively simple and useful when the cost and effort of taking all the households in a selected PSU is not much higher than collecting data from a limited number of samples in the selected PSU. This method will result in most circumstances in a very unpredictable total sample size as the number of households in the sample can only be determined after the selection of the PSU. Single stage sampling also results in sample error estimations that are considerably larger than those of simple random samples when equal sample sizes are selected. An alternative to examining all households in the selected PSU is to select a sample of households for data collection. Because there is a first stage of sampling – determining which PSU to include in the sample – and a second stage – when selecting households in each of the chosen PSU – this method is referred to as **two-stage** sampling (Levy 1999). A sample obtained in such a way could look as shown in Figure 5.2.

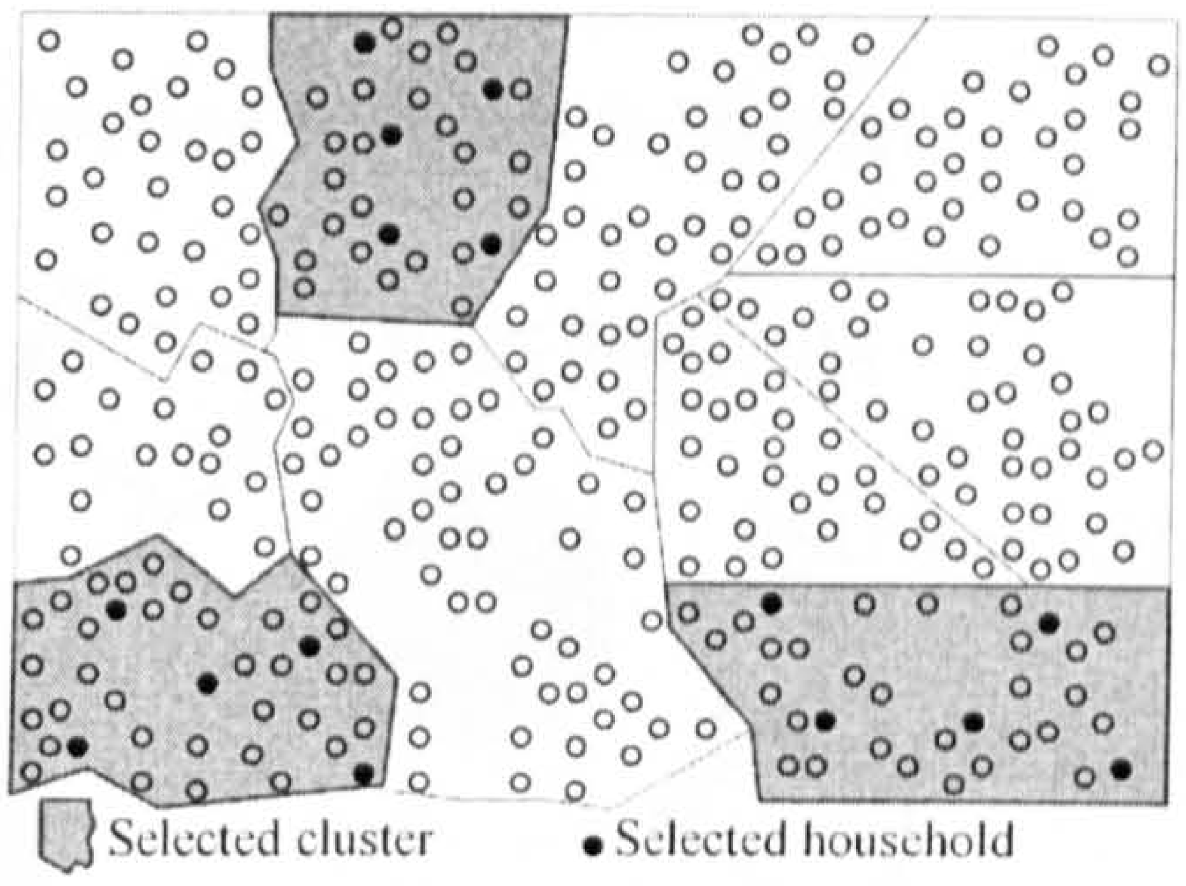


Figure 5.2: Example of two stage sampling

Figure 5.3 shows a practical application of two-stage sampling. This was part of the field-testing of the survey methodology in Laos which will be discussed later in this thesis.

Each stage of the selection process can use different methods of sampling. These selection methods will determine the probability of each household to be included into the sample. If the selection process gives households different probabilities of being included in the sample, the analysis has to take account of these differences. Giving each individual BSU a **weight** when analysing the data obtained corrections for these different probabilities. Sampling strategies avoiding the need for such corrections, are referred to as **self-weighted**, meaning that each sample in the population has an equal probability to be selected. This 'equal probability of selection' method or EPSeM (Kish 1965) allows for simple statistical analysis because sample weights are not required in the analysis. The EPSeM philosophy dates from before the advent of computers as this approach reduces considerably the required calculus to obtain survey results.

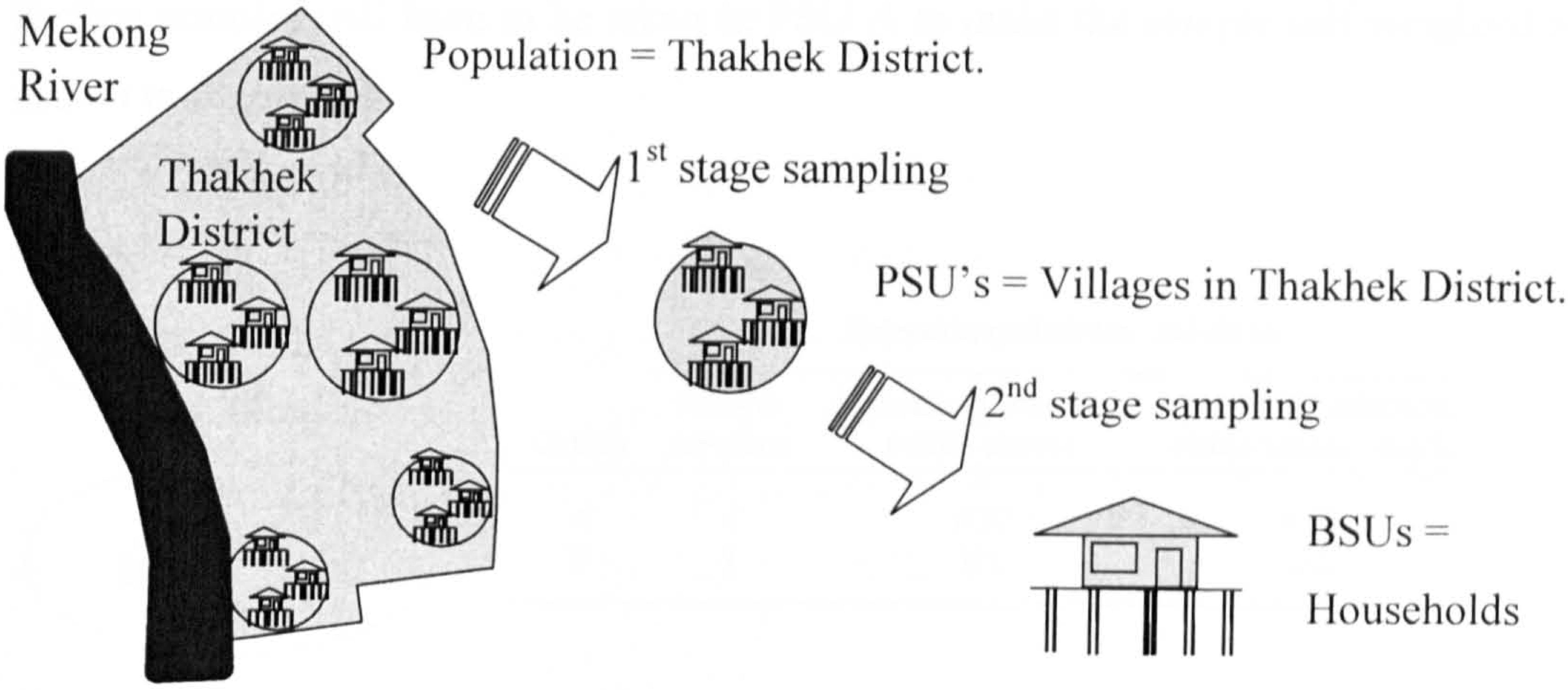


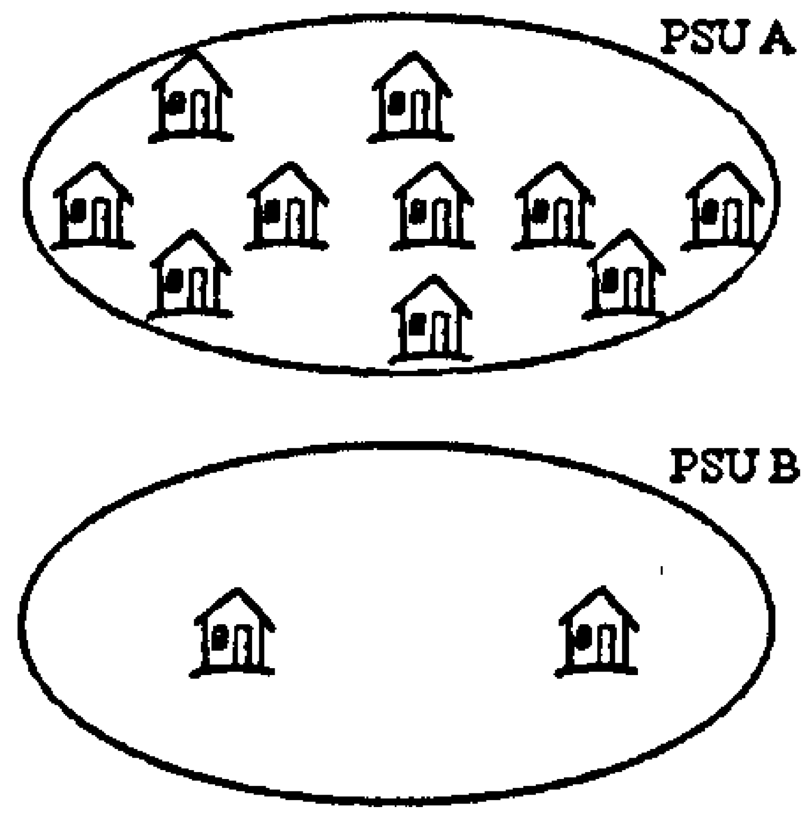
Figure 5.3: Two stage sampling plan in a household survey held in Thakhek district of Laos PDR

Nowadays statistical programs can easily deal with weighted data. So when sample weights are easily determined, obtaining EPSeM samples are not essential from a computing point of view (Fitch 2000). There are other reasons to stick to an EPSeM design as explained later. Aiming for a self-weighted sample will often reduce the weight variance and hence increase the precision (Fitch 1999). A more pragmatic reason is found in the four rules postulated by Scott (1987) for sampling work in developing countries. In a manual written for the Demographic Health Survey he states: "*Samples should be self-weighting unless there is a good reason to depart from the principle in specific cases. The need to compute weights and carry them in a database, the need to assess when and how they should be applied, and to correctly report their use, can be a appreciable burden on staff*" (Scott 1987). Other reasons not to depart from the EPSeM design are discussed later in this chapter.

Selecting PSU with each an equal probability of selection

There are two main approaches to **EPSeM** in two-stage cluster sampling. The first is the **SRS of the PSU** in the population. This means that PSU A in Figure 5.4 has exactly the same change of selection as PSU B. One household is then selected from each PSU. Selecting one household in PSU A will give each household in this PSU a one in ten chance of being included in the overall sample compared to one in two for the households in PSU B. This can be corrected by giving the information collected from that one household in PSU A a weight equal to the number of households its represents. To make this an EPSeM sample the sample size taken in PSU A would have to be five times larger than that taken in PSU B. If one sample is taken in PSU

B, five samples will have to be taken in PSU A to make the sample self-weighted as shown in Figure 5.4.



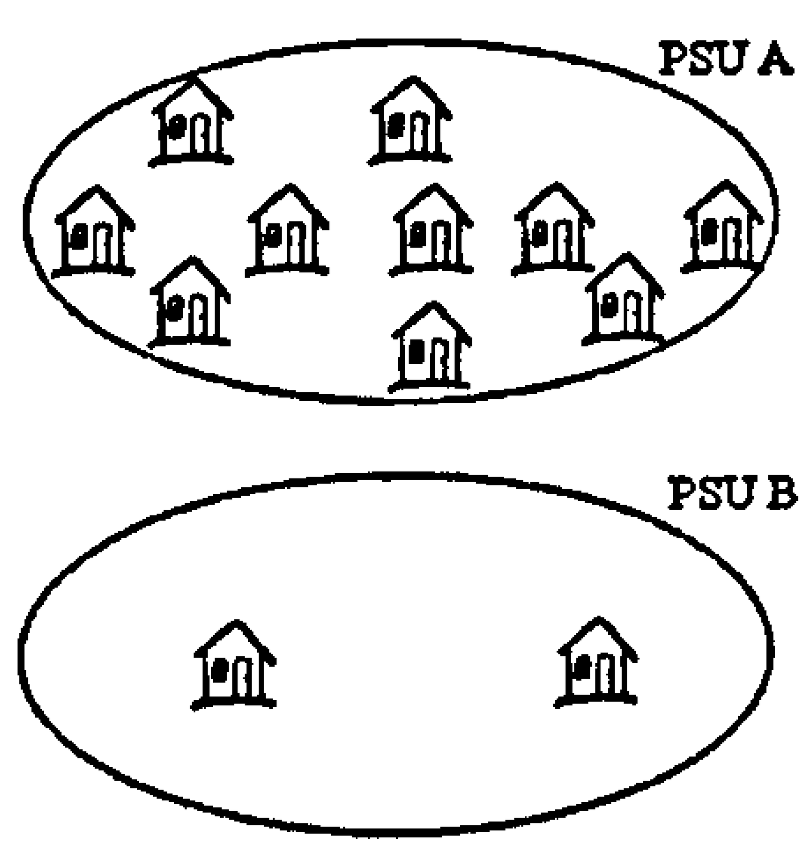
	Selection probability (relative)		
Cluster	Cluster selection	Household selection within cluster	Household selection within whole sample
A	1	1/10	1/10
B	1	1/2	1/2

Figure 5.4: PSU selected with equal probability

This type of sampling requires the calculation of the sample size for each of the selected PSUs in such a way that the sample size in each PSU is relative to the size of that PSU. This way of taking samples makes the overall sample size more predictable but can still result in sample error estimates that are considerably larger than simple random samples using equal overall sample sizes. This is particularly true when there is a large variation in PSU sizes. It is also possible to reduce the sample error by selecting PSU with a probability proportionate to their size as discussed below.

Selecting PSU with a probability proportionate to their size

Another more commonly used method is to select the PSU with a probability proportionate to its size (PPS). This means that in Figure 5.5 PSU A has five times more chance of selection compared to PSU B because it has five times more households. By selecting one household in each PSU each selected household will have an identical chance of being selected in the sample.



	Selection probability (relative)		
Cluster	Cluster selection	Household selection within cluster	Household selection within whole sample
A	10	1/10	1
B	2	1/2	1

Figure 5.5: PSU selected with a probability proportionate to PSU size

This approach not only simplifies the process but also reduces the sampling error[2] and makes the sampling error more predictable.

How the PPS selection of PSU is done in practice can be found in Annex E.

Cluster sampling is not restricted to a two-stage sampling design. **Multiple-stage sampling** (i.e. more than two stages) is possible but would increase the complexity of the sample plan and would require specialized help from people trained in survey statistics. As the *WaSH* survey design targets people that are statistically untrained, multiple-stage sampling falls outside the context of this dissertation.

Disadvantages of cluster survey design

Cluster sampling makes data collection for household surveys more feasible but alongside these practical advantages some disadvantages exist:

- A substantial increase in sample size is required to maintain the same confidence interval attained by SRS when using cluster surveys.
- The measure of size used for the PPS sampling of PSUs can be different from the BSUs. For example, if the BSU is children under five months the number of children for each PSU might not be known. Households can be a measure of size on the assumption that there is a linear proportional relation between the number of BSUs and the measure of size. It is possible to add a correction by weighting the sample when the true measure of size for PPS becomes available during data collection.
- Often, estimates of size are used rather than the known size, which can reduce the statistical validity of the sample result (Hansen 1953; Kalton 1987; Thomsen 1986). The use of estimated measures of size is very common in low-income areas because of the lack of more precise data (Kalton 1987). Thomsen et al. (1986) indicated that for outcomes with hardly any clustering in the population the 'true' range of error could be less than measured. However when the outcome is highly clustered the difference between the real and the estimated size can lead to a significant underestimation of the confidence interval of the result. Kalton (1987) suggested use of the term probability proportioned to estimated size

[2] To reduce the error when using an alternative measure of size for PPS, the particular measure has to be closely related to the study variable (Lehtonen 1995)

(PPES) when an estimated measure of size is used. Detailed analysis of this problem falls outside the context of this thesis.

- If the survey population is not homogeneous, which is often the case, there is the possibility that some PSUs group BSUs with a particular value which can be significantly higher or lower than the population average. This clustering increases the possibility that the survey values are not representative of the population. This uncertainty, expressed as the design effect, will increase the range of error in the survey measurement.

5.3.2 Chosen sample strategy for WaSH survey methodology

At this stage the sample plan chosen for the survey methodology is an EPSeM two-stage cluster sample design in which the first stage selects the PSU with a probability proportionate to the size of each PSU and a second stage in which identical '*take* sizes' are randomly sampled from each selected PSU. The '*take*' in this thesis is defined as the number of BSU selected in a PSU. In this way, the sum of the *take* in each PSU equals the total sample size.

The simplicity and its statistically sound sample design are not the only motivation for opting for such a sample design. This choice is also based on other aspects of this design which will be discussed later in this chapter.

5.4 Sample size determination

5.4.1 Sample distribution

As discussed before in Chapter 2 the information collected from the population is dichotomous. This means that the outcome follows a binomial distribution. However, given a large enough sample size the 'Central Limit Theorem' in statistics gives a theoretical anchor to the assumption of normality (Kirkwood 2003). This theorem states, in effect, that if statistics such as means, totals and proportions are based on large enough sample sizes, their sampling distribution tend to be normal or Gaussian, irrespective of the nature of the underlying distribution of the original observations such as the binomial distribution in this case.

5.4.2 Required sample size

Equation 5.1, on the next page, enables the determination of the sample size required for a simple random sampling determining proportion in a target population based on a normal distribution of the variable of interest:

	Exact	Approximate
Sample size for proportions with relative deviation	$n \geq \dfrac{z^2 N P_x (1-P_x)}{(N-1)\varepsilon^2 P_x^2 + z^2 P_x (1-P_x)}$	$n \geq \dfrac{z^2 (1-P_x)}{\varepsilon^2 P_x}$
Sample size for proportions with absolute deviation		$n \geq \dfrac{z^2 P_x (1-P_x)}{d^2}$

n	Sample size
z	Reliability coefficient or amount of standard errors away from the mean
N	Population size
ε	Relative deviation (%) of the result, $\varepsilon\ P_x = \mathrm{d}$
d	Absolute deviation (% points) of the result or PRECISION
P_x	Unknown population proportion for outcome

(Lemeshow 1990; Levy 1999)

Equation 5.1 : Sample sizes in simple random samples

The maximum sample size needed for a simple random sample with a precision of 10% points (d) would be when P_x = 50%. The sample size needed would be 96 basic sampling units as calculated in Equation 5.2.

$$n = \frac{z^2 p(1-p)}{d^2} = \frac{1.96^2 \times 0.5(1-0.5)}{0.1^2} = 96$$

z=1.96	Reliability coefficient or amount SE away from the mean
d=0.1	Absolute deviation (% points) of de result or PRECISION
n	Sample size

Equation 5.2: Simple random sample size calculation

Simple random sampling can be impractical and costly for use in a large scale population survey. As mentioned before a two-stage EPSeM sampling strategy selecting PSU with a PPS offers a good alternative. The decreased certainty of how representative cluster samples are compared with an SRS usually results in larger sampling errors for cluster sampling with an equal sample size.

The error is increased by a factor called the design effect ratio (*deff*). Including the design effect, the equation for the standard error becomes:

$$s = \sqrt{\frac{p(1-p)}{n} deff} \quad \Rightarrow \quad n \geq \frac{p(1-p)}{s^2} deff$$

(Bennett 1991)

s standard error SE
p proportion
n sample size
$deff$ design effect

Equation 5.3: Standard error and sample size in cluster sampling

Design effect and rate of homogeneity

The choice of sampling strategy has by far the greatest effect on both the variance and the cost (Kish 1965). Equation 5.1 can not directly calculate the sample size of cluster surveys. Cluster samples are characterised by a higher homogeneity than a simple random sample of the same population, which tends to increase the sample error. Generally, cluster samples have a larger standard error, which requires them to have a larger sample to obtain similar standard errors to those obtained with simple random sampling. This difference (*Deff*) is defined as 'the ratio of the actual sampling variance to the variance of a simple random sample with the same number of units' (Yates 1981).

$$Deff = \frac{\text{actual sample variance}}{\text{variance of a SRS with the same number of basic sampling units}} = \frac{V_{cs}}{V_{srs}}$$

Deff design effect (true)
Vcs Variance of the cluster sample
Vsrs Variance of a SRS with the same number of BSUs in the same population.

Equation 5.4: True design effect

In reality, we can only work with information from our sample. Moreover, we use cluster sampling to avoid having to take simple random samples from the population. Without a simple random sample for comparison, the true design effect would be only a theoretical concept. In practice, the design effect is calculated as '*the ratio of the actual sample variance taking into account cluster sampling design of the data collection*' to '*the variance of the same sample calculated as if it were a random sample*'. This gives us an idea of the possible true design effect, which in real sampling will stay unknown.

$$deff \cong \frac{\text{cluster sample variance}}{\text{variance of the same BSUs calculated as a simple random sample}} = \frac{\hat{V}_{CS}}{\hat{V}_{srs}}$$

deff. design effect (measured)

V_{cs} Variance of the cluster sample $\hat{V}_{CS}$ Estimated value of the cluster sample variance

$\hat{V}_{SRS}$ Estimated value of the sample variance of sampled BSUs calculated as a simple random sample.

Equation 5.5: Practical calculation of design effect

Design effects express partially the clustering of the measured characteristic in the population. Clustering of the sample can reinforce or attenuate this effect. Obtaining values for design effects is **empirical**, through a survey of a similar design. What exactly has to be similar is not clear from literature but the sample size in each cluster, in this document referred to as *take*, and the number of clusters appear to be important factors in the design of a two-stage cluster sampling (Bennett 2001).

As the *deff* is a property of clustering in the population as well as the ways in which the sample is selected, values of *deff* will only be useful if obtained from a survey that is 'identical' to the planned one. For this thesis *deff* values were calculated from existing 'Demographic Health Surveys' (DHS) by Macro OCR and 'Multiple Indicator Cluster Surveys' MICS by UNICEF. These surveys have considerably higher number of clusters and *take* sizes than those aimed at in the *WaSH* survey methodology. To make the obtained *deff* values useful, the value relating to the clustering of the measure of interest in the population have to be isolated from the part that relates to the way the sample is taken. Kish (1965) suggested doing this by introducing a generalised *intra-cluster correlation coefficient*, termed '*rate of homogeneity*' (*roh*). It aims at removing the effects of average cluster sizes in the comparison of results across different variables and population domains.

$$deff = \frac{V_{cs}}{\hat{V}_{srs}} = \frac{V^2(\hat{\bar{X}})}{\hat{S}^2_{srs}/n} = 1 + \rho(\bar{b} - 1) \quad \Rightarrow \quad \rho = \frac{deff - 1}{\bar{b} - 1} \text{ (Kish 1965)}$$

(du V Florey 1993; Kish 1965)

deff. design effect

V_{cs} Variance of the cluster sample

$\hat{V}_{SRS}$ Variance of the same sampled BSUs calculated as for a SRS.

$\hat{S}_{SRS}$ Standard error of same sample, calculated as for a SRS.

$\hat{\bar{x}}$ Estimated mean of the measured variable

n sample size

ρ rate of homogeneity *roh*

$\bar{b}$ average size of *take*

Equation 5.6: Design effects and rate of homogeneity *roh*

As indicated in Equation 5.6 Kish postulated that *roh* as a property of the population is related to *deff* only by the average *take* size and not by the number of clusters.

$$\bar{b} = \frac{\sum b_i^2}{\sum b_i}$$ (Kalton 2005,p.107)

$\bar{b}$ Average *take*

b_i Sample size in cluster *i*

Equation 5.7: Average *tak'* with a substantial variety of *take* sizes among cluster

When the there is a wide variety in the *take* sizes among the different PSUs, OCR Macro (1996) recommended the use of Equation 5.7 to calculate the average *take* size to determine the value of ρ. Kalton et al (2005,p.107) describe this approach as if a weighted average has been taken of all the takes in a cluster survey. This assumes that the survey is self-weighted (EPSeM) Montanari (1993) looked at how valid ρ was in expressing the rate of homogeneity within the population rather than within the sample. He found that the ρ will only do this under certain conditions and states that there might be better indicators for this. To do this he introduced a variable *k* as shown below.

$$\hat{deff} = (1-k)\left[1 + \rho(\bar{b}-1)\right]$$ (Montanari 1993)

Equation 5.8: Variable 'k' in relation between *deff* and *ρ*

The formulae for *k* is complex and theoretical but Montanari (1993) states that under particular circumstances *k* becomes negligible and Equation 5.8 approximates Kish's formula in Equation 5.6.

The conditions relevant to the *WaSH* survey methodology are:

- *The outcome is a proportion* (Cochran 1977; Kalton 1979). This is the case as all the *WaSH* indicators are dichotomous;
- *Allocation of PSU to the strata is proportional to the stratum sizes.* The designed survey methodology aims to apply only explicit stratification which means that for each stratum (e.g. rural, urban) a separate survey has to be done. This means that each survey has only one stratum and this condition is fulfilled at all times;

- *The PSU selection probabilities are proportional to the domain sizes and the domain considered is the population.* In the survey no data is provided for the analyses of different domains so the population is the domain, which together with PPS selection of the PSU provides a partial condition for k to become negligible;
- *Samples within PSU have similar precision than SRS with negligible sampling fractions.* This requires that sampling in the PSUs is similar to SRS and the *take* size is negligible compared to the number of BSU in the PSU;
- The last condition for use of Kish's formula is that the *sampling plan results in a self-weighted (EPSeM) data set*;
- To increase the chance for $k \approx 0$ Montanari further recommends the use of equal *take* size in the self-weighted sample design (Montanari 1993).

With the sample design of the *WaSH* survey design as described in section 5.3.2 on page 168, the conditions and even the supplementary recommendation by Montanari for $k \approx 0$ are fulfilled. This means that Equation 5.6 as initially formulated by Kish (1965) can be used. Including k would dramatically increase the statistical complexity without clear benefits. To keep the statistics simple in the survey method the suggestion by Kish (1965) to use empirical studies to improve the estimates of *deff,* using the rate of homogeneity ρ as defined in Equation 5.6 is preferred in this study.

Thomsen (1986) looked at the effect of using an out-of-date measure of PSU size in determining ρ and noticed that the differences can be considerable. This aspect of an out-of-date measure of size in determining ρ is not so important for the *WaSH* survey methodology and its analysis but very important for the validity of the abstraction of ρ from new or existing surveys where the measurement of PSU size used might not be correct. In existing data sets, information on discrepancies between real and estimated value of the measure of PSU size is rarely available to calculate possible corrections.

The value of ρ will vary between a maximum of one for high design effects and 0 for none. The lower the value for ρ, the higher is the homogeneity in the population and consequently the intra- and inter-cluster homogeneity. *Roh* can occasionally become negative if clusters result in a lower variance than in simple random sampling (Kish 1965). This situation is however exceptional.

Empirical determination of deff *and* roh

To have a better insight into the 'typical' design effects for access to water and sanitation and to determine their typical *roh*, data from some existing Demographic Health Surveys and Multiple Indicator Cluster Survey data sets were analysed. The datasets initially used were DHS for the Dominican Republic 1994, DHS Kenya 1998 and MICS Moldavia 2000. After the cleaning of the data, a new binomial value was created representing access to water and sanitation based on the information available in the DHS and MICS data sets. All variables were given a value '1' for access and a value '0' for non-access.

The first variable '*wat_jmp*' was formed by using the JMP definition of access to an improved and non-improved water source (Table 4.1).

The second variable '*san_jmp*' used the JMP definition of access to improved sanitation (Table 4.16). A third variable '*wat_time*' used only collection time to measure access. This is based on the water collection graph by Cairncross and Feachem (1993) as illustrated in Graph 4.7 Access was determined by water collection times less or equal to 30 minutes (≤30 min) and non-access by collection times greater than 30 minutes (>30 min). A final variable '*wat_comb*', a function of '*wat_jmp*' and '*wat_time*' as shown in Table 5.1, was created to approximate the water indicator created for the *WaSH* survey method.

wat_jmp	*wat_time*	⇨	*wat_comb*
I	I		I
I	0		0
I	.		.
0	I		0
0	0		0
0	.		0
.	I		.
.	0		0
.	.		.

'I' = access;
'0' = non-access,
'.' = missing value

Table 5.1: Creating variable '*wat_comb*' based on variable '*wat_jmp*' and '*wat_time*'

The design effects for the different variables varied from 10.7 for variable '*san_jmp*' in the DHS Kenya 1998 to 4.6 for '*wat_jmp*' in the same survey. Most (three-quarters) of the values for *deff* were between 6.1 and 8.1. To calculate ρ with Equation 5.6 the average *take* size ($\bar{b}$) has to be known. As water, sanitation and hygiene data are collected as an extra add-on to these surveys the rate of non-response to these questions is high. This non-response rate is considerably higher for sanitation and hygiene behaviour. This makes the calculation of $\bar{b}$ and *deff* from these data sets unreliable. The DHS for the Dominican Republic 1994 was chosen to calculate ρ because out of all the datasets analysed it had the lowest non-response rate (13%, n=8831) for access to water (*wat_comb*) and (13%, n=8807) for access to sanitation (*san_jmp*). Consequently the figures for *deff* and the average *take* ($\bar{b}$) sizes are likely to be more reliable. The data set was also the only one that contained information on drinking and non-drinking water, which made it possible to create access indicators similar to those considered for the *WaSH* survey as explained in Chapter 4. That chapter showed that the *WaSH* indicator for access to water has a geographical determinant (the distance to the source through the water collection time) as shown in Figure 5.6. This geographical determinant is the reason why high design effects are expected for the access to water indicator.

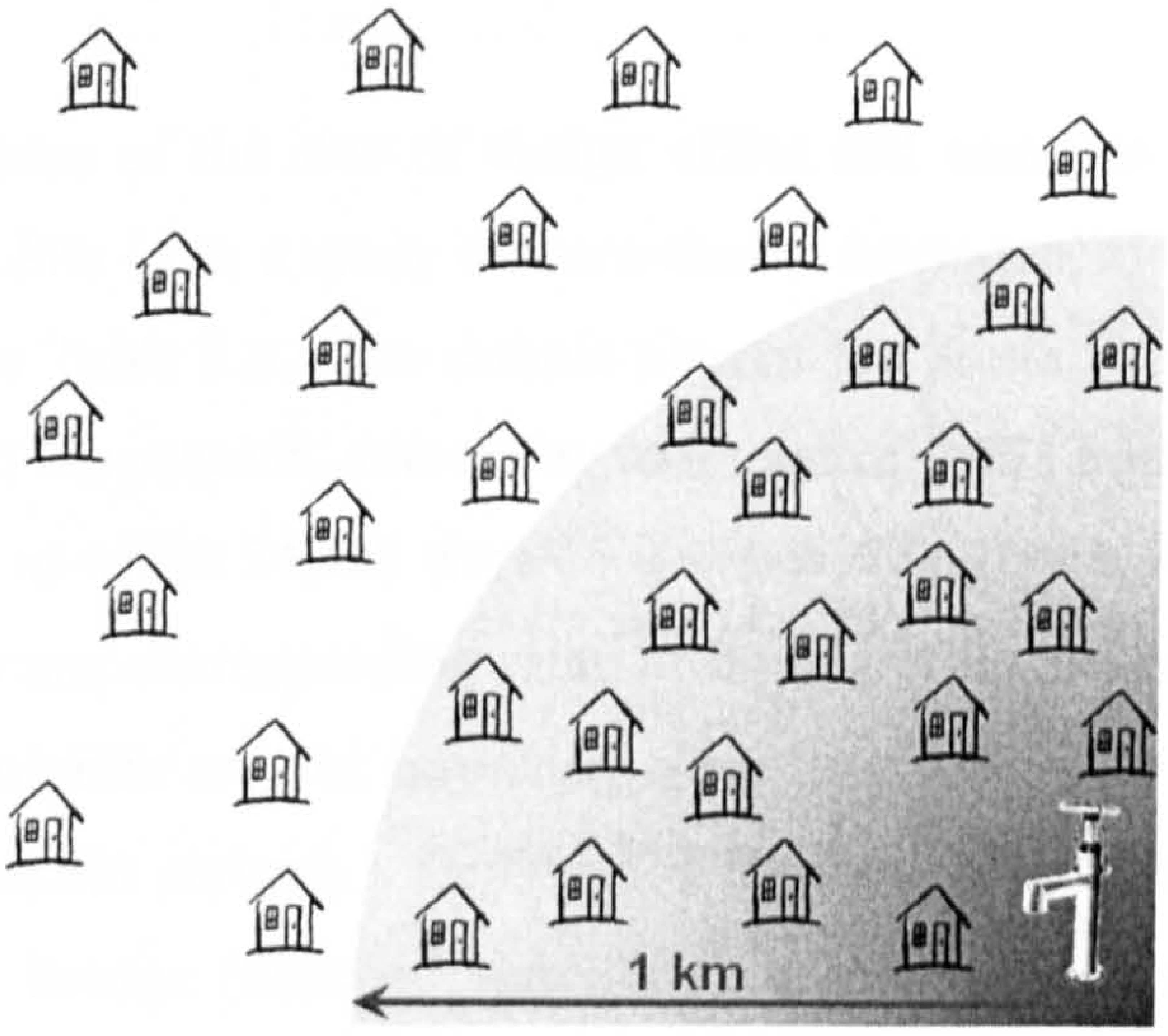


Figure 5.6: Distance to source as a determinant of clustered household data

The data set yielded a design effect for access to water of 7.64 which gives an estimate fort the rate of homogeneity of:

$$\hat{\rho} = \frac{deff - 1}{\bar{b} - 1} = \frac{7.64 - 1}{22.4 - 1} \cong 0.31$$

ρ rate of homogeneity *roh*
deff. design effect
$\bar{b}$ *take* or sample size in clusters

Equation 5.9: Experimental determination of *roh*

In this particular dataset the *deff* and *roh* for the access to water was bigger than that for access to sanitation (see Table 5.2). However all other data sets showed a higher design effect for access to sanitation compared to access to water. This would indicate a higher clustering for sanitation. This high spatial clustering for sanitation may be due to the pattern of diffusion of latrine adoption, which spread from person to person and goes along road networks and outwards from major population centres (Jenkins 1999). However there was also a higher non-response rate for sanitation-related questions compared to water-related questions. The impact of the non-response rate is difficult to assess.

Variable	deff	n	#PSU	$\bar{b}$	roh
san_jmp	5.30	8807	395	22.3	0.20
wat_comb	7.64	8831	395	22.4	0.31

Table 5.2: *Roh* obtained from DHS Dom. Rep. 1994

To have a better idea of the size of design effect and compare it with other cross sectional surveys, data from a study of intra-cluster homogeneity in a South African Survey is shown in Table 5.3. The sample plan of the South African study had 360 clusters, each of 25 households, amounting to a total of 8,847 households and around 45,000 individuals of which 24,452 were 16 years or older (Qaba 1999).

The design effects and corresponding rates of homogeneity for accommodation and socio-economic variables are not surprising since they follow the patterns observed, generally, in household surveys. *Deff* values for type of housing, which includes shacks, traditional houses (thatched rondavels), formal houses and other types of housing, are quite high. The *deff* values for socio-economic variables are high, although not as high as the accommodation *deff.* For example, the *deff* associated with the 'currently employed' status is 5.36.

Variable	Sample size (n)	Avr. deff	Avr. RoH
Accommodation			
Type of house	24'427	15.04	0.5907
Roof material	24'387	14.59	0.5678
Demographic			
Gender	24'452	2.26	0.0188
Race	24'452	16.21	0.6399
Socio-Economic			
Employed	13647	5.36	0.2206
Health			
Consultation	2'475	1.31	0.0046
Agriculture			
Type of land ownership	2'829	10.71	0.1443

(Qaba 1999)

Table 5.3: Design effects for selected variables in a South African Study

Since groups with the same socio-economic status tend to live together (wealthy people in high-income areas and poor people in low-income areas) this is not surprising. Gender cuts across classes similarly; hence there is not much clustering expected, which explains why the *deff* values are not high (2.26). For race on the other hand *deff* are expected to be greater in South Africa as segregation of racial groups was legalised in the resent past. The use of individual persons over 16 years as BSU results in interviewing multiple persons per household. For variable relating to accommodation as done in Qaba's (1999) analysis, this might not be appropriate as it is likely to increase the clustering effect if these samples were not properly weighted for these outcomes.

Another study of childhood diarrhoea clustering within villages revealed design effects ranging from 2.07 (95% CI 1.26-3.19) in Zambia to 7.93 (95% CI 5.16-11.52) in Indonesia (Katz 1993). According to this study, design effects were strongly dependent on cluster size.

The DHS sampling methodology

One of the criteria for the rate of homogeneity to be representative of the population in the survey is that it that it relates to a similar population as that from which it was derived.

The general policies for the DHS surveys are (ORC Macro 1996):

1. 100% nationally representative (some conditional minor exclusions allowed).
2. Self-weighted probability sample by using an equal probability of selection method (EPSeM). Sample in which each BSU has an equal probability of being selected. (Over-sampling allowed for measurements with low prevalence).
3. Use of pre-existing sample frames (if available and adequate).
4. Simplicity of design.

DHS is designed for a target sample size of 5000 to 6000 women age 15-49 while a maximum of 10% under-sampling is allowed due to under-representation in the compilation of the sample frame (at the household mapping and listing stage) or due to non-response. DHS allows implicit stratification by enabling the distinction of five to six regions with around 1000 BSUs sampled in each region.

The sample size in each cluster in the DHS surveys is called the *take* and for the general purpose DHS design the *take* is '20' for urban and 30-40 for rural women.

Sampling without a sample frame (i.e. without detailed household listings) is not accepted in DHS as it is considered a false economy and leads to non-probability samples. Because the Demographic Health Survey (DHS) concentrates on demographic and reproductive data, it targets women aged 15-49. It is difficult to evaluate whether and how concentrating on this group might influence the rate of homogeneity for in the *WaSH* survey method, but it seems unlikely to be significant.

A Demographic and Health Survey collects data on individuals residing in private households, but an up-to-date list of such individuals or households is generally not available. The sampling frame used for the first stage of sampling in most Demographic and Health Surveys is based on a list of non-overlapping area units that cover the entire national territory. Essential characteristics of these units, for framing purposes, are well-defined boundaries and clearly delineated maps. Each area unit also has a unique identification code. It must also have a current or estimated measure of size (population and/or number of households). Other characteristics such as the urban/rural classification usually exist for each area unit and these may be used for stratification purposes (Vaessen 2005).

5.4.3 Sampling with a detailed sample frame

One of the aims in testing the survey methodology is to obtain 'real' design effects for comparison with those obtained from the DHS survey. DHS surveys differ from the survey methodology being developed not only in the sample size and the number of clusters used, but also in the type of indicators used as explained in Chapter 4.
To obtain a measured *deff* and *roh,* sampling with a sample frame will be used. For this, only sites of a recent DHS-, MICS-survey or national census were considered as they were more likely to have an up-to-date sample frame which could be used.
As explained in Chapter 7 none of the field trials planned under such conditions took place and alternative sample frames had to be build.
In cluster surveys, the sample size is the product of the number of clusters and the average *take* as shown in Equation 5.10.

$$n = \sum_{i=1}^{c} b_i \cong c.\overline{b}$$

n Total sample size
c number of clusters
b_i *take* size of cluster i
$\overline{b}$ average *take* or average sample size in each cluster

Equation 5.10: Sample size in relation to number of clusters and average *take* size

Application of sampling theory to cluster design optimization

For a cluster sample design, we need to determine not only the overall sample size but also the number of clusters and the *take* sizes which determine the sample size (Equation 5.10). Formulae to determine these values could not be found in literature. The calculations used in this section to determine the sample size are written out in full using the equations referred to earlier in this chapter.
The values of c and $\overline{b}$ have to take into account the design effect while obtaining the desired precision (Equation 5.3). The aim is usually to find an optimum which is suitable for most circumstances while optimising the design for a low cost. Combining Equation 5.10 with Equation 5.3 as shown leads to Equation 5.11 as suggested by Bennett (Bennett 1994).

$$n = c.\bar{b} \text{ (Equation 5.10)} \quad \text{and} \quad n \geq \frac{p(1-p)}{s^2} deff \text{ (Equation 5.3)}$$

$$\Rightarrow$$

$$c.\bar{b} \geq \frac{p(1-p)}{s^2} deff$$

$$c \geq \frac{p(1-p)}{s^2 \bar{b}} deff \quad \text{(Bennett 1994)}$$

Equation 5.11: Calculation of the number of clusters required based on *deff*

Using Equation 5.11 by Bennett in conjunction with Equation 5.6 postulated by Kish allows rewriting the equation for the number of clusters needed as a function of *roh* and the *take*.

$$c = \frac{p(1-p)deff}{s^2 \bar{b}} \text{ (Equation 5.11)} \quad \text{and} \quad deff = 1 + \rho(\bar{b} - 1) \text{ (Equation 5.6)}$$

$$\Rightarrow$$

$$c = \frac{p(1-p)(1+\rho(\bar{b}-1))}{s^2 \bar{b}}$$

Equation 5.12: Calculation of the number of clusters required based on *roh* and *take*

Adding to this formula a known maximum acceptable sample error of 10 percentage points at a 95% confidence level and calculating the sample size for the worst case, which is when the prevalence is 50%, gives:

$$s = \frac{d}{z} = \frac{0.1}{1.96} = 0.051$$

$$\text{if } p = 0.5 \text{ or } 50\% \Rightarrow$$

$$c = \frac{p(1-p)}{s^2 \bar{b}}\left(1 + \rho(\bar{b} - 1)\right)$$

$$c = \frac{0.5(1-0.5)}{0.051^2 \bar{b}}\left(1 + \rho(\bar{b} - 1)\right)$$

$$c = \frac{96(1-\rho) + 96 \cdot \rho \cdot \bar{b}}{\bar{b}}$$

d absolute error = 0.1 or 10% points
z reliability coefficient = 1.96 (for 95% confidence level)
c number of clusters
p expected proportion (0.5 for worst case scenario)
s standard error
$\bar{b}$ average *take*

Equation 5.13: Sample size (number of clusters) as a function of *roh* and *take*

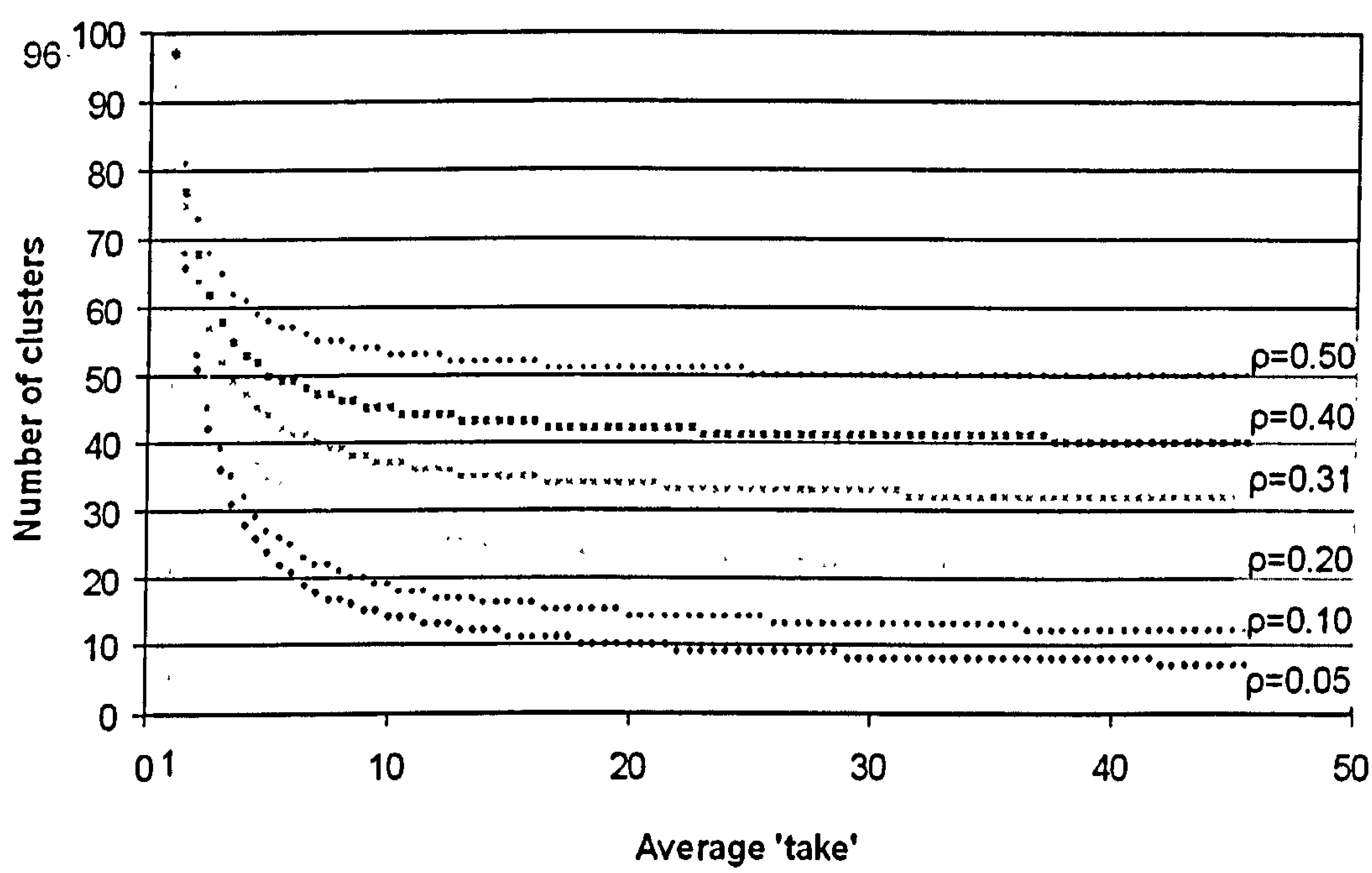
The plot in Graph 5.1 based on Equation 5.13 shows the number of clusters required based on the average *take* for different rates of homogeneity. Because the number of clusters can only be an integer, the graph is not smooth. It is clear from Graph 5.1 that there is no optimum number of clusters for a given average *take*. To determine the minimum cluster required for a *roh* of 0.31, Equation 5.13 can be used while increasing the *take* towards infinity. As shown in Equation 5.14 this minimum is 30 clusters for ρ=0.31.

$$c = \frac{96(1-\rho)+96.\rho.\bar{b}}{\bar{b}}$$

$$\lim_{\bar{b}\to\infty} \frac{96(1-\rho)+96.\rho.\bar{b}}{\bar{b}} = 0+96.\rho \cong 30 \text{ (with } \rho = 0.31)$$

Equation 5.14: Minimum clusters required

This would mean that the rate of homogeneity is an important factor in determining the minimum number of clusters required in a cluster sample survey.



Graph 5.1: Number of clusters in relation to *take* size for different *roh*

To calculate the maximum required number of clusters, the limits for the function in Equation 5.13 are calculated with the *take* at its minimum value of one.

$$c=\frac{96(1-\rho)+96.\rho.\bar{b}}{\bar{b}} \quad \text{with } \bar{b}=1$$
$$c=96(1-\rho)+96\rho=96$$

Equation 5.15: Maximum number of clusters required

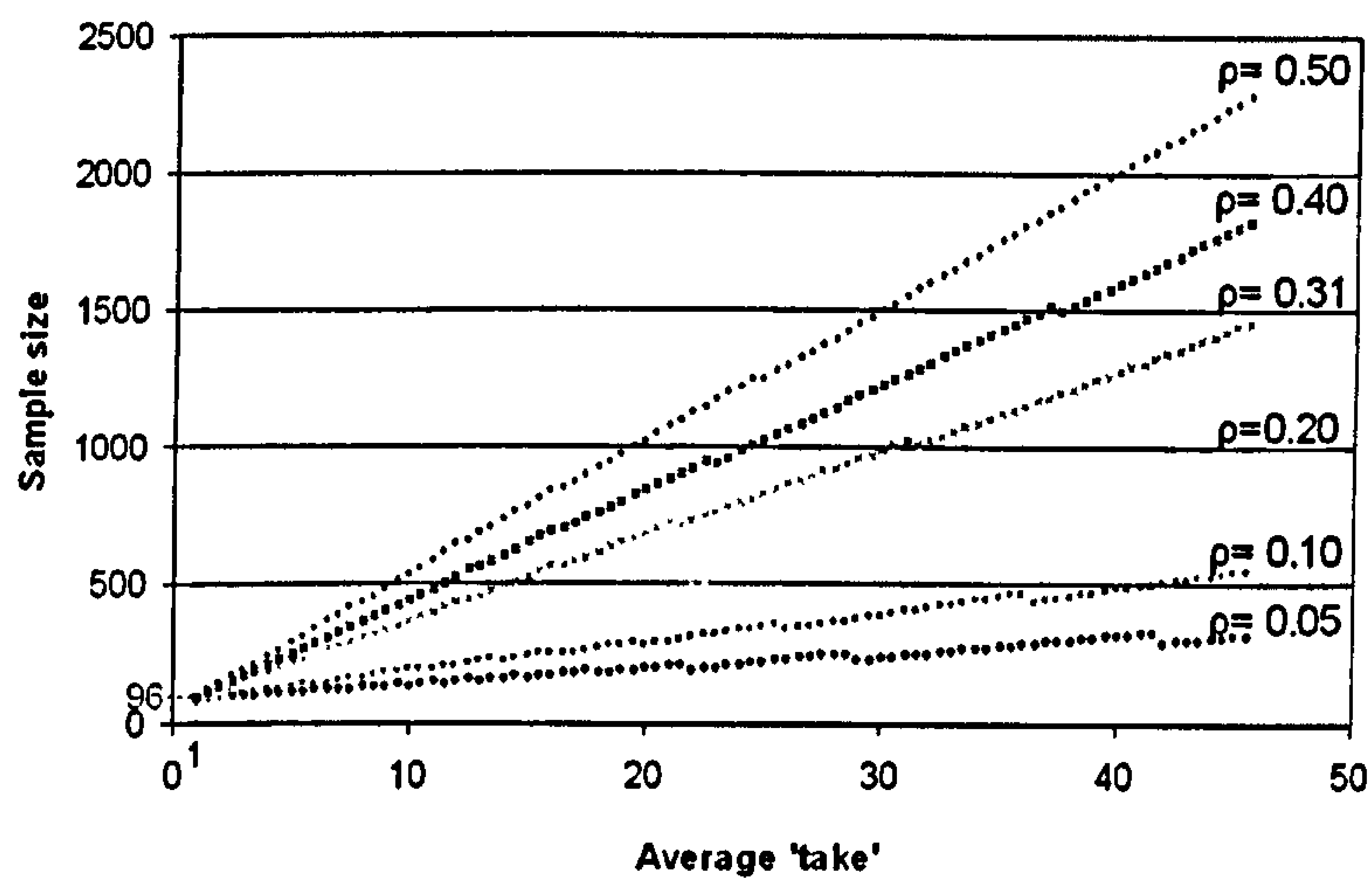
This gives a maximum of 96 clusters, which is independent of the rate of homogeneity as shown in Equation 5.15 and Graph 5.1. This is also the value of the sample size required for a SRS with the same sample error estimates as shown in Equation 5.16 . This is logical as a sampling scheme with a *take* of one BSU is equivalent to SRS.

$$n \geq \frac{z^2 P_x(1-P_x)}{d^2} \quad \text{(Equation 5.1)}$$
$$n \geq \frac{1.96^2 \times 0.5(1-0.5)}{0.1^2}=96.0$$

n Sample size
z Reliability coefficient (1.96)
d Absolute deviation (10 % points)
P_x Prevalence (0.5)

Equation 5.16: Sample size for equivalent SRS

It can be shown that for a two-stage EPSeM cluster sample design, fulfilling the requirements set out by Montanari (1993) for which k≈0 (see Equation 5.8) the minimum number of clusters required is equal to the sample size required for an equivalent SRS multiplied by the rate of homogeneity in the population for the measure of interest.



Graph 5.2: Sample size in function of the *take* for different values of *roh*

Based on the number of clusters and the size of the *take*, no optimum sample size can be found. The only figure that can be determined is the minimum sample size as shown in Equation 5.17. This sample size as well as the sampling is equal to that required for SRS, which at the beginning of the chapter was ruled out as not feasible on the basis of impracticality and cost.

$$n \geq \frac{p(1-p)}{s^2} deff \text{ (Equation 5.3)} \quad \text{and } deff = 1+\rho(\bar{b}-1) \text{ (Equation 5.6)}$$

$$\Rightarrow$$

$$\begin{aligned}
n &= \frac{p(1-p)}{s^2}(1+\rho(\bar{b}-1)) \text{ and } s = \frac{d}{z} \\
&= \frac{z^2 p(1-p)}{d^2}(1+\rho(\bar{b}-1)) \\
&= Lim_{\bar{b}\to\infty} \frac{z^2 p(1-p)}{d^2}(1+\rho(\bar{b}-1)) \\
&= \infty \\
n &= \frac{z^2 p(1-p)}{d^2}(1+\rho(\bar{b}-1)) \text{ and } \bar{b} = 1 \\
&= \frac{1.96^2 \times 0.5^2}{0.1^2}(1+0) \\
&= 96.0
\end{aligned}$$

n Sample size
p Prevalence (0.5)
b *take*
ρ rate of homogeneity
s standard error
d Absolute deviation (10 % points)
z reliability coefficient (1.96)

Equation 5.17: Minimum and maximum sample size calculation

Introduction of survey costs in the next section enables the determination of optimal sample sizes.

5.4.4 Cost factor in the cluster-take relation

The main reason for cluster sampling is to minimise the cost of the survey. There are three costs regarding a survey:

- **Fixed** cost, which varies little with the design of the survey, such as licences, cost of training, supervision, and design of questionnaires, etc.
- **Variable** costs, which do vary with the design in a two-stage cluster survey can be divided into:
    - Costs which are fixed for each individual **cluster,** such as transport costs for the clusters, salaries of the drivers, and;

- Cost fixed for each individual **sample unit,** including cost of reproducing survey forms, salaries of the surveyors, cost of imputing the data into the database, etc.

In cluster surveys the assumption appears to be that the cost of each additional cluster substantially increases the overall survey budget despite the reduction in the overall sample size. To determine the optimum number of clusters and required *take*, the fixed costs are of little interest. Introducing two different costs, one for the cluster and one for the BSU, does not allow us to calculate an optimum *take* or cluster size as it gives one unknown variable more than there are independent equations. Only the relation between these two costs is important to calculate an optimal sample size, so instead of two different costs, their cost ratio factor is introduced as shown in Equation 5.18.

$$C_{survey} = C_{fixed} + C_{variable}$$
$$C_{survey} = C_{fixed} + (C_{PSU} \times c) + (C_{BSU} \times n)$$
$$C_{variable} = (C_{PSU} \times c) + (C_{BSU} \times n) \text{ and } n = c \times \bar{b}$$
$$\frac{C_{variable}}{C_{BSU}} = (\frac{C_{PSU}}{C_{BSU}} \times c) + (\frac{C_{BSU}}{C_{BSU}} \times c \times \bar{b})$$
$$\text{if } C_{BSU} = 1 \text{ and } \frac{C_{PSU}}{C_{BSU}} = C_{ratio} \Rightarrow$$
$$C_{variable} = (C_{ratio} + \bar{b}) \times c$$

C_{survey}	Cost of the total survey
C_{fixed}	Costs independent of design
$C_{variable}$	Cost dependent on survey design
C_{PSUr}	Cost per extra PSU (cluster)
C_{BSU}	Cost per extra BSU
C_{ratio}	Cost per PSU divided by costs per BSU
c	number of selected PSU's (clusters)
n	sample size
$\bar{b}$	average *take*

Equation 5.18: Various costs in cluster sampling

$$C_{variable} = (C_{ratio} + \bar{b}) \times c \text{ (Equation 5.18) and } c = \frac{96(1-\rho) + 96.\rho.\bar{b}}{\bar{b}} \text{ (Equation 5.12)}$$
$$\Rightarrow$$
$$C_{variable} = (C_{ratio} + \bar{b}) \times \frac{96(1-\rho) + 96.\rho.\bar{b}}{\bar{b}}$$
$$\frac{d(C_{variable})}{d(\bar{b})} = d\left(\frac{C_{ratio} 96(1-\rho)}{\bar{b}} + C_{ratio} 96.\rho. + 96(1-\rho) + 96.\rho.\bar{b}\right)$$
$$\frac{d(C_{variable})}{d(\bar{b})} = -\frac{C_{ratio} 96(1-\rho)}{\bar{b}^2} + 0 + 0 + 96.\rho$$
$$\frac{d(C_{variable})}{d(\bar{b})} = \frac{96.\rho.\bar{b}^2 - C_{ratio} 96(1-\rho)}{\bar{b}^2}$$

Equation 5.19: Formula for variable survey cost and its differentiation

The maximum or minima for the variable survey cost are reached when the differential in Equation 5.19 reaches 0, as calculated in Equation 5.20.

$$\frac{d(C_{\text{variable}})}{d(\bar{b})} = 0$$

$$\frac{96.\rho.\bar{b}^2 - C_{ratio}96(1-\rho)}{\bar{b}^2} = 0$$

$$96.\rho.\bar{b}^2 = C_{ratio}96(1-\rho)$$

$$\bar{b}^2 = \frac{C_{ratio}96(1-\rho)}{96.\rho}$$

$$\bar{b} = \sqrt{\frac{C_{ratio}(1-\rho)}{\rho}}$$

Equation 5.20: *Take* size for minimum survey costs

Equation 5.20 will rarely result in an integer. As fractions of a whole sampling unit are not permitted in a sample design in which all PSU have the same *take*, the outcome of the equation will have to be rounded up to the closest integer.
Table 5.4 shows the calculation of the *take* (b) as a function of the cost ratio for a *roh* of 0.31 obtained through Equation 5.20. This results rarely in an integer and as the *take* is identical for each PSU this figure is rounded up to the nearest whole figure. Using that figure in Equation 5.12 gives the number of clusters required (c) in the third column, which also requires rounding up. The total sample size (n) in the last column is derived from multiplying column (b) with (c) as in Equation 5.10.
Table 5.4 shows optimum sample size for different cost ratios. For some of these values, Table 5.5 illustrates changes to these optimum sample sizes for changing values of *roh*. Small variations in *roh* seem to give large changes in the optimal sample sizes. The values for the *take* and the number of clusters in Table 5.4 and Table 5.5 are rounded up to the nearest integer, as explained before. The results for Equation 5.20 for different values of *roh* and a cost ratio of 450 are also shown in Graph 5.3. The cost ratio of 450 used to determine the optimum cluster size is based on estimates of vehicle rental cost, fuels and salary of drivers versus salary cost of the surveyors and reproduction cost of questionnaire and other survey material in nutritional surveys in which the author participated. This cost ratio was higher than

expected and is probably slightly overestimated as nutritional surveys are likely to have lower sample costs and higher cluster cost, in comparison with the *WaSH* survey method.

C_{ratio} (ρ=0.31)	b	c	n
50	11	36	396
60	12	36	432
70	13	35	455
80	14	35	490
90-100	15	35	525
110	16	34	544
120-130	17	34	578
140	18	34	612
150-160	19	34	646
170-180	20	34	680
190	21	34	714
200-210	22	33	726
220-230	23	33	759
240-250	24	33	792
260-270-280	25	33	825
290-300	26	33	858
310-320	27	33	891
330-340-350	28	33	924
360-370	29	33	957
380-390-400	30	33	990
410-420-430	31	32	992
440-450-460	32	32	**1024**
470-480-490	33	32	1056
500-510-520	34	32	1088
530-540-550	35	32	1120
560-570-580	36	32	1152
590-600-610	37	32	1184

Table 5.4: Sample size calculation for ρ= 0.31

Due to lack of other estimates, this cost ratio will be used to determine the sample size for the field trials. More detailed cost ratios and *roh* will have been obtained from the field trials and are presented in Chapter 8.

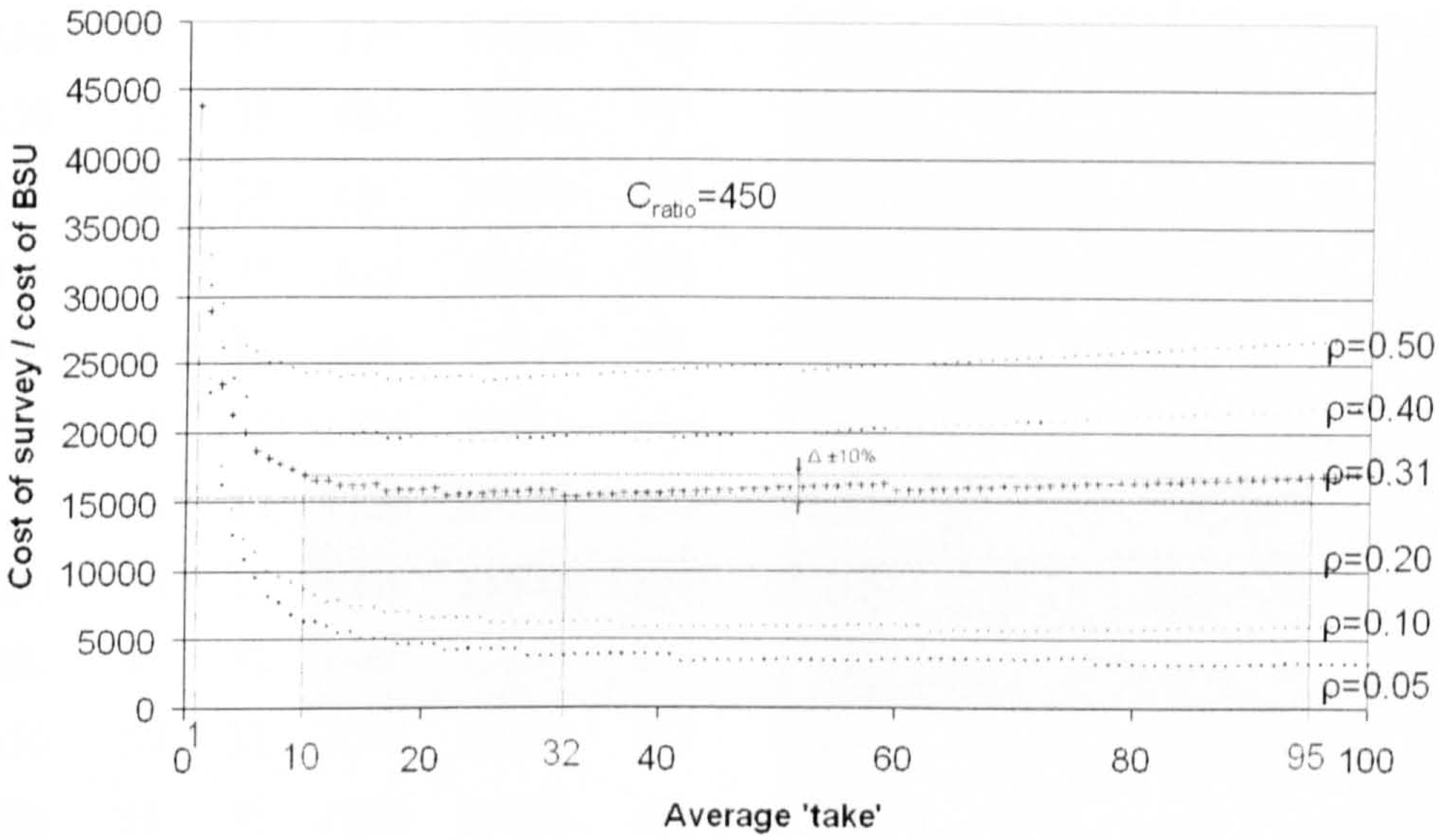
C_{ratio}= 300				C_{ratio}= 450				C_{ratio}= 600			
ρ	b	c	n	ρ	b	c	n	ρ	b	c	n
0.50	18	51	918	0.50	22	51	1122	0.50	25	50	1250
0.40	22	42	924	0.40	26	41	1066	0.40	31	41	1271
0.31	26	33	858	0.31	32	32	1024	0.31	37	32	1184
0.20	35	22	770	0.20	43	21	903	0.20	49	21	1029
0.10	52	12	624	0.10	64	11	704	0.10	74	11	814
0.05	76	7	532	0.05	93	6	558	0.05	107	6	642

Table 5.5: Various *take* sizes for different rates of homogeneity and cost ratios

A sample of 32 clusters is only two clusters more than the minimum of 30 required for a *roh* of 0.31 as determined in Equation 5.14. Using the obtained *take* in Equation 5.6 gives a *deff* of 10.6 as shown below:

$$\begin{aligned} deff &= 1+\rho(b-1) && \text{(Equation 5.6) with } \rho = 0.31 \\ &= 1+0.31(32-1) && b = 32 \text{ (for } C_{ratio}=450\text{)} \\ &= 10.6 \end{aligned}$$

Equation 5.21: Determining *deff* for a $C_{ratio} = 450$



Graph 5.3: Survey cost as a function of the *take* for various values of *roh*

Graph 5.3 shows no clear single optimum *take* size but a whole series of values which result in similar costs. For a *roh* of 0.31 the ideal *take* for a cost ratio of 450 is 32, according to Table 5.4 and Table 5.5 but values between 10 and 95 will give similar survey costs (within 10% difference) according to Table 5.6. The shaded area in Graph 5.3 shows these same values. Table 5.6 shows the values from Graph 5.3 in a table format with the last column showing the variation from the minimum survey costs. Costs in the tables below are expressed as a factor of the cost of one sample, as in the graphs.

Cost ratio	*Take*	Clusters	Sample size	Survey cost	% above optimum
450	1	96	96	43296	181%
450	2	63	126	28476	85%
450	3	52	156	23556	53%
450	4	47	188	21338	38%
450	6	41	246	18696	21%
450	8	39	312	17862	16%
450	10	37	370	17020	10%
450	15	35	525	16275	6%
450	20	34	680	15980	4%
450	25	33	825	15675	2%
450	30	33	990	15840	3%
450	**32**	**32**	**1024**	**15424**	**0%**
450	35	32	1120	15520	1%
450	40	32	1280	15680	2%
450	45	32	1440	15840	3%
450	50	32	1600	16000	4%
450	55	32	1760	16160	5%
450	60	31	1860	15810	3%
450	65	31	2015	15965	4%
450	70	31	2170	16120	5%
450	75	31	2325	16275	6%
450	80	31	2480	16430	7%
450	85	31	2635	16585	8%
450	90	31	2790	16740	9%
450	95	31	2945	16895	10%
450	100	31	3100	17050	11%
450	105	31	3255	17205	12%
450	110	31	3410	17360	13%

Table 5.6: Sample size for a C_{ratio} =450

Cost ratio	*Take*	Clusters	Sample size	Survey cost	Percentage difference
340	32	32	1024	11904	-23%
350	32	32	1024	12224	-21%
360	32	32	1024	12544	-19%
370	32	32	1024	12864	-17%
380	32	32	1024	13184	-15%
390	32	32	1024	13504	-12%
400	32	32	1024	13824	-10%
410	32	32	1024	14144	-8%
420	32	32	1024	14464	-6%
430	32	32	1024	14784	-4%
440	32	32	1024	15104	-2%
450	***32***	***32***	***1024***	***15424***	***0%***
460	32	32	1024	15744	+2%
470	32	32	1024	16064	+4%
480	32	32	1024	16384	+6%
490	32	32	1024	16704	+8%
500	32	32	1024	17024	+10%
510	32	32	1024	17344	+12%
520	32	32	1024	17664	+15%
530	32	32	1024	17984	+17%
540	32	32	1024	18304	+19%
550	32	32	1024	18624	+21%
560	32	32	1024	18944	+23%
570	32	32	1024	19264	+25%
580	32	32	1024	19584	+27%
590	32	32	1024	19904	+29%
600	32	32	1024	20224	+31%
610	32	32	1024	20544	+33%

Table 5.7: Cost ratios using a 32x32 sample

The cost of surveys using a 32 x 32 design at other cost ratios is shown in Table 5.7. The relation between the survey cost and the cost ratio as shown in Table 5.7 is derived from Equation 5.18.

$$\begin{aligned} C_{variable} &= (C_{ratio} + \bar{b}) \times c \\ &= (C_{ratio} + 32) \times 32 \\ &= 32C_{ratio} + 1024 \end{aligned}$$

Equation 5.22: Survey cost in relation to the cost ratio in a 32 x 32 sample

5.4.5 Hypothesis testing between two surveys

Cross-sectional household surveys often form the basis for comparison in time or by geographical locations with other surveys. This is particularly true with monitoring progress toward Vision 21 and the MDG.

To measure differences between surveys accurately, a different approach is required which does not look at the sampling error in the outcome of either survey but that of the measured difference between them. The null-hypothesis that the results of the two surveys are not significantly different can only be ruled out if 0 is not included in the confidence intervals (CI) of the difference (p_1-p_2) between the obtained access figures p_1 and p_2. If so, the difference between the survey means can not be attributed to chance alone.

The following is the calculation of the sample size needed to measure progress in the same population over time. It assumes that the required precision should enable to measure a difference of 10 percentage points similar to the precision used in the previous examples. The sample size is also calculated for the worst case scenario in which both survey measure a prevalence around 50%, which will result in the largest sample size. Although the rate of homogeneity can change if the level of coverage of services changes, it is assumed constant in the calculation below. The sampling design is also assumed to be identical in both surveys.

$$d = z_{(1-\alpha/2)} \sqrt{\frac{p_1(1-p_1)D_1}{n_1} + \frac{p_2(1-p_2)D_2}{n_2}}$$

d	CI of (p_1-p_2)
z	reliability coefficient
p_1 & p_2	proportion survey 1 & 2
D_1 & D_2	Design effect in survey 1 & 2

Adapted from Lemeshow (1990) page 10

$n_1 \cong n_2$ Sample sizes in the two surveys are assumed the same

$\rho_1 \cong \rho_2$ Rates of homogeneity are equal in the two surveys

$deff_1 \cong deff_2$ Design effects estimated be identical as similar sampling schemes are used

$$d = z_{(1-\alpha/2)}\sqrt{\frac{p_1(1-p_1)deff}{n} + \frac{p_2(1-p_2)deff}{n}}$$

z= 1.96 (95% confidence interval)

$$d = z_{(1-\alpha/2)}\sqrt{\frac{deff}{n}\left(p_1(1-p_1) + p_2(1-p_2)\right)}$$

d = 0.1 (10% CI for Δp)

$$n \geq z^2_{(1-\alpha/2)}\frac{p_1(1-p_1)+p_2(1-p_2)}{d^2}deff$$

max value for $(p_1(1-p_1)+p_2(1-p_2))$ is 0.5 see Lemeshow (1990,p.118)

$$n \geq z^2\frac{0.5}{d^2}D =$$

$$n \geq 1.96^2\frac{0.5}{0.1^2}D =$$

$$n \geq 192D =$$

Using $n = c \times \bar{b}$ (Equation 5.10)

$$c \times \bar{b} \geq 192(1+\rho(\bar{b}-1)) =$$

and $D = (1+\rho(\bar{b}-1))$ (Equation 5.6)

$$c \geq \frac{192(1+\rho(\bar{b}-1))}{\bar{b}} =$$

$$c \geq \frac{192(1-\rho+\rho\bar{b})}{\bar{b}} =$$

$$c \geq 192\frac{1-\rho+\rho\sqrt{\frac{C_{ratio}(1-\rho)}{\rho}}}{\sqrt{\frac{C_{ratio}(1-\rho)}{\rho}}} =$$

using $\bar{b} = \sqrt{\frac{C_{ratio}(1-\rho)}{\rho}}$ (Equation 5.20)

$$c \geq 192\frac{\sqrt{\rho}(1-\rho)+\rho\sqrt{C_{ratio}(1-\rho)}}{\sqrt{C_{ratio}(1-\rho)}} =$$

$$c \geq 192\left(\frac{\sqrt{\rho}(1-\rho)}{\sqrt{C_{ratio}(1-\rho)}}+\rho\right) =$$

$$c \geq 192\left(\frac{\sqrt{0.311}(1-0.311)}{\sqrt{450(1-0.311)}}+0.311\right) =$$

$$c \geq 64$$

with:

C_{ratio}= 450

ρ= 0.311

$$\bar{b} = \sqrt{\frac{C_{ratio}(1-\rho)}{\rho}} =$$

$$\bar{b} = \sqrt{\frac{450(1-0.311)}{0.311}} =$$

$$\bar{b} \cong 32$$

Equation 5.23: Sample size to measure differences in two surveys

The maximum sample size in Equation 5.23 will be required when $(p_1(1-p_1)+p_2(1-p_2))$ is 0.5. Using Equation 5.20 the required *take* (b) is 32, which is identical to the *take* obtained before. Using this value in Equation 5.23 gives the numbers of clusters required (c=64) and the product of both gives a sample size of

2048 BSU. This value is twice the sample size required in the example before and this is entirely obtained by doubling the number of clusters. For surveys that need to be able to measure ‘progress’, sample size increases substantially. As in the span of this research it was not planned to make comparable surveys using the same method, this sample size increase was not be taken into account for the planned field trials.

5.5 Alternative sampling methods

The following are brief descriptions of interesting approaches which are getting increasing attention in the scientific community. They could be part of the efforts to obtain data for the WASH sector but after reflection they will not be part of a *WaSH* survey method at this stage as explained below. They each aim to offset some of the limitations found in the traditional sampling methods described above.

5.5.1 EPI-sampling

Traditional household sampling methods based on Simple Random Sampling require all the households as BSU to be identified prior to the sampling. The cluster sampling methods commonly used in household surveys limit the requirement for detailed lists of households to the selected clusters, but require a current measure of size for each PSU in the target population. Creating detailed lists for each selected PSU still requires considerable effort, skill, and resources, which are not always available in low-income countries.

In low-income countries, accurate and up-to-date sampling frames are rarely available and existing sample frames may not be reliable especially in situations where:

1. maintaining the household lists proves difficult (often there is no administrative structure for reporting changes),
2. minorities, disadvantaged communities or migrants tend to be excluded,
3. there is a high rate of migration, as in peri-urban areas or among populations displaced due to events such as natural disasters.

Alternative household sampling methods, which do not use detailed sample frames, have been developed to cater for settings where sample frames are unavailable or impractical as is common in developing countries. To date one of the most popular spatial sampling methods, adopted by the WHO for use in low-income countries, is the EPI method, named after the Expanded Programme of Immunization. This makes use of a modification of PPS cluster sampling developed originally in the USA (Serfling 1965) and modified for use in the smallpox eradication programmes in West Africa (Henderson 1973).

The EPI method (as this method is generally known) is fully described by Henderson and Sundaresan (1982) but can be simply described as follows. A number of clusters (e.g. communities, villages) are chosen with a probability proportionate to their size, and then an equal number of selected households is surveyed in each of the selected clusters. In each chosen cluster, the EPI method selects:

1. a location near the centre of the community,
2. a random direction (often defined in the field by spinning a bottle or pen) and
3. a random household along the chosen direction pointing outwards from the centre of the community to its boundary.
4. In subsequent steps, carried out iteratively, the closest household (door to door) to that determined in the previous step is chosen and checked for compliance with the inclusion criteria.
5. Step 4 is repeated until the required number of households is surveyed.

The sample size for EPI can be determined by using Equation 5.3 and *deff* values of two, obtained by previous vaccination surveys (Henderson 1973). The required confidence interval was determined at ±10%.

$$
\begin{aligned}
n &= \frac{p(1-p)}{s^2} deff \\
&= \frac{0.5(1-0.5)}{0.05^2} 2 \\
&= 200
\end{aligned}
$$

ci	confidence interval ±10%
z	reliability coefficient 1.96 (95% confidence interval)
s	standard error $ci/z = 0.1/1.96 = 0.05$
p	proportion 0.5 (worst case scenario)
n	sample size
deff	design effect 2 (Henderson 1973)

Equation 5.24: Calculation of EPI sample size with *deff* =2

When designing the EPI-sampling method "*the developers...were determined to use 30 clusters*" (Levy 1999). This meant that here was no real optimisation process in designing the EPI method (Bostoen 2006). Given the number of clusters the *take* size can be determined by rewriting Equation 5.11 as shown below.

$$c = \frac{p(1-p)deff}{s^2 b} \quad \text{(Equation 5.11)}$$

$$\begin{aligned} b &= \frac{p(1-p)deff}{s^2 c} \\ &= \frac{0.5(1-0.5)2}{0.021^2 \times 30} \\ &= 6.4 \Rightarrow 7 \end{aligned}$$

deff design effect of 2 (Henderson 1973)
p expected prevalence 0.5 (as a worst case scenario)
z reliability coefficient 1.96 (95% confidence interval)
ci confidence interval ±10%
s standard error $ci/z = 0.1/1.96 = 0.05$

Equation 5.25: *Take* size calculation for EPI-sampling based on 30 clusters

Equation 5.25 gives the required *take* size for 30 clusters and a value of two for the *deff*. As the first stage sampling in EPI is PPS the method uses an identical *take* in each cluster. This results in a sample size of 30x7=210 which is slightly higher than the sample size calculated in Equation 5.24. Adapting the same equation it is possible to show that the 30 x 7 sample design is suitable for *deff* up to 2.2 through the increase in samples caused by rounding up of the *take* size as calculated in Equation 5.26.

$$\begin{aligned} n &= \frac{p(1-p)}{s^2} deff \\ deff &= \frac{s^2}{p(1-p)} n \\ &= \frac{0.05^2}{0.5(1-0.5)} 210 \\ &= 2.2 \end{aligned}$$

ci confidence interval ±10%
z reliability coefficient 1.96 (95% confidence interval)
s standard error $ci/z = 0.1/1.96 = 0.05$
p proportion 0.5 (worst case scenario)
n sample size of 210 = 30 x 7 Equation 5.24
deff design effect

Equation 5.26: Calculation of *deff* for the 30 x 7 EPI cluster sample design

EPI-sampling has enabled WHO and UNICEF to measure the coverage of their childhood immunisation programmes and has also been adapted to measure nutritional status (Sullivan 1994). There is no doubt that EPI-sampling has been instrumental in increasing immunisation coverage worldwide (Kalton 1988; Singh 1995). Concerns regarding EPI-sampling are that it is not a true probability design (Kalton 1988; Turner 1996,p.199) and as such, sample weights can not be used if the survey proved not to be self-weighted (Kalton 1988). The method has a clear starting-point-bias (Bennett 1993,p.27) and initially disregarded non-response (Dabis

1989; Kalton 1988). The biggest criticism regards its second-stage sampling[3] which has the potential for surveyor bias (Brogan 1994; Kalton 1988; Lemeshow 1985a). While these problems might result in various biases the method clearly over-represents households in high density areas (Mann 2002) and those situated closer to the population centre (Bennett 1993; Henderson 1973). Statisticians had some doubts on the EPI method, mainly pertaining to the validity of the confidence interval (Kalton 1987) until computer simulations provided some indications of its precision (Bennett 1994; Lemeshow 1985b).

The simplicity ease and relative low cost of EPI-sampling has made this method very popular; so popular that it has been applied even when sample frames exist (Singh 1996; Stoeckel 1997). Its main advantage is that it avoids costly listing operations (Kalton 1987).

Unfortunately this method has often been used inappropriately due to the lack of understanding of its statistical and analytical limitations as well as the lack of appropriate alternative sampling methods (Bennett 1993; Fitch 1999; Kalton 1987; Stoeckel 1997). The use of EPI-sampling has therefore on occasions resulted in non-representative data on which perhaps erroneous decisions and conclusions were made. Suggestions have been made to improve and adapt the EPI method (Bennett 1994; Fitch 1999; Henderson 1982; Kalton 1987; Milligan 2004; Turner 1996). However most of these improvements resulted in undermining the simplicity of the original method. Furthermore, it is difficult to assess whether these improvements resulted in more representative or accurate data. Some of the variants, such as the compact segment method discussed later are close to probability samples, but due to a higher clustering in the sample they are not suitable for measuring access to water and sanitation due to the design effects of this variable.

Suitability of EPI-sampling for the WaSH survey methodology

Data collection in the *WaSH* survey methodology would be significantly simplified if a data collection such as EPI-sampling could be used. The 30 x 7 EPI-sampling design is based on values for *deff* ≤ 2 though in practice values of ≤ 2.2 can be

[3] The first-stage sampling is PPES (page 167) receives little criticism apart from the 30x7 sample size, as it is very similar to PPS in traditional sampling. The main criticism regards the 'random walk' in the second stage' which makes it a non-probability design.

accepted (Equation 5.26). However for access to 'improved' water sources *deff* can be higher than seven (Table 5.2) which makes the EPI design unsuitable as it stands. Adapt such sampling strategy to the *WaSH* 32 x 32 sample, as determined in Table 5.4, was considered. However EPI-sampling uses a non-probability sample, which means that the probability of selecting each BSU in the sample is unknown. The properties of sampling methods which are not strictly random can only be analysed by an exhaustive set of simulations such as those attempted by Lemenshow et al. (Lemeshow 1985b) and Bennet et al. (Bennett 1994). Despite their utility these computer simulations were very limited in scope because of the algorithms (Mann 2002) and the data used. To explore further the potential of EPI-sampling and all suggested improvements (Bennett 1994; Fitch 1999; Henderson 1982; Kalton 1987; Milligan 2004; Turner 1996), look at the possibility of a 32 x 32 sample, and as well test other creative sampling methods, a new sampling simulator was developed.

To make it a more general tool, the simulator was built in a computer environment generally referred to as 'Geographic Information System' or GIS. This would enable the author to programme the behaviour of a surveyor walking through a rural village, and in the future, through urban areas such as the slum area shown in Figure 5.7.

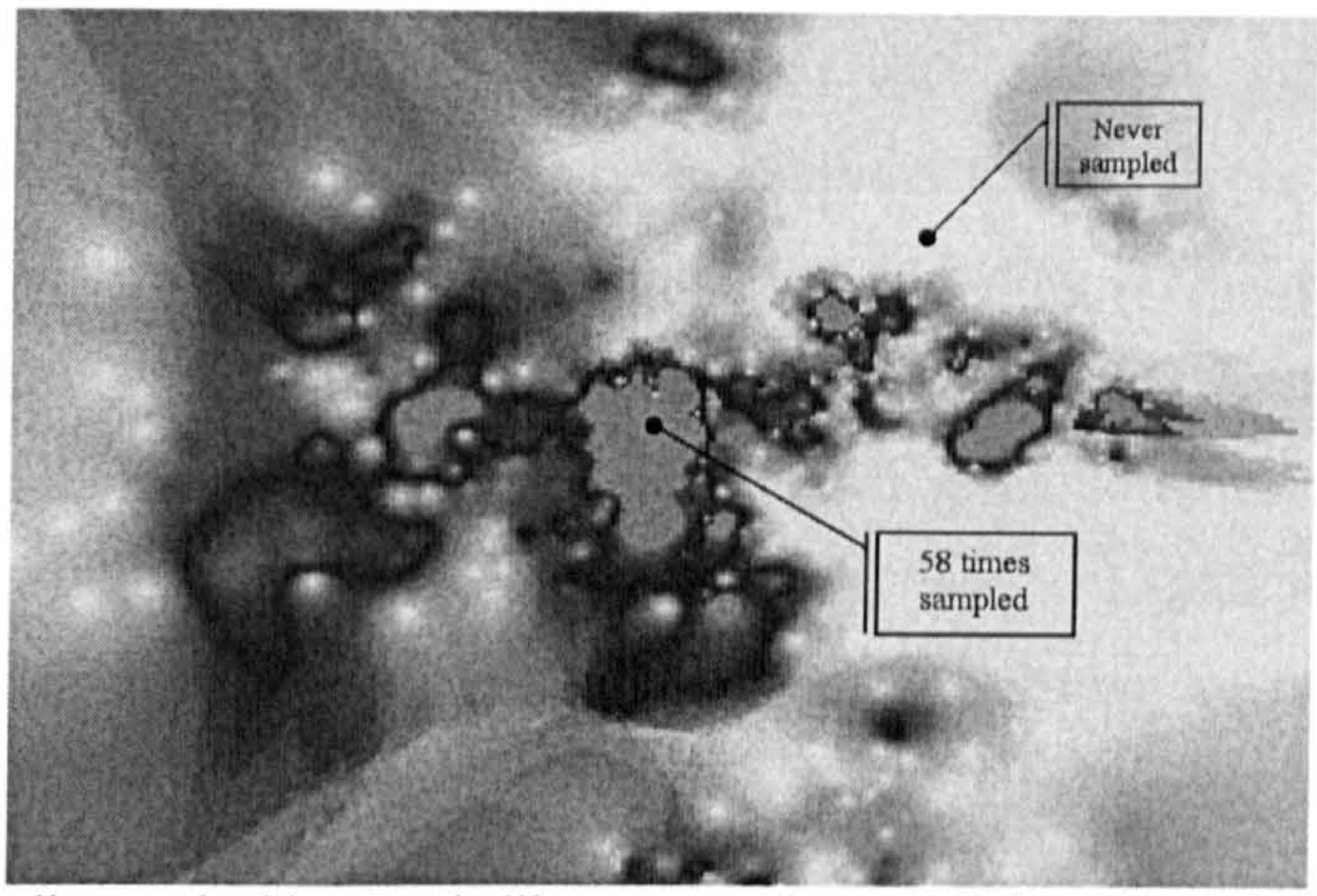
Kibera informal settlement in Nairobi, Kenya, reproduced with permission G. Sartori UNDP, G. Nembrini Geneva Foundation

Figure 5.7: 3D model of part of Kibera informal settlement from high resolution satellite images

Such 3D models can be easily obtained from high-resolution satellite images, while any available geo-referenced data set can be used to test the sampling method.

Looking for the required skills to programme such a simulator, various organisations, companies, and institutions were contacted to enquire for their interest in developing this kind of project. Although there was an interest in practical applications based on outcomes of such project, like programming PDA/GPS systems to collect data, there was little interest in doing the 'ground work' for such a sampling method. Through the UK National Physical Laboratory based in Teddington, Middlesex, we obtained various contacts mainly within UK universities. The most positive result was received from University College London (UCL) who after discussion were keen on an "*innovative approach to the use of a GIS environment*" (Morley 2001) and proposed it as a suitable research project for their MSc students in geomatic engineering.

Gareth Mann, an MSc student in geomatic engineering at UCL, built an initial simulator based on the author's initial task specification given in Annex D. While the simulator was useful in indicating some problems regarding EPI-sampling, the student did not follow the various steps initially agreed in the development of the simulator. These consisted mainly in verifying the statistical validity at each step of the design. This resulted in a program that was not written according to the requested specification, and which contained 'statistical' errors. The lack of experience in structured programming led the student to write inefficient algorithms which combined MS Visual Basic Script ™ (VBS) and ARC-Objects™. At times simulations took more than 32 hours to run through 254 iterations for one cluster. These long simulation times did not allow the number of tests required to examine various sampling strategies. Moreover, choices in the development environment limited simulation to 254 iterations per batch, which is far away from the targeted 10,000 simulations per cluster. Simulating EPI-sampling in the simulator showed clearly that there was a starting point bias and a higher probability for houses in a in higher density area to be selected as shown below.



EPI-sampling method in a rural village as one cluster (250 iterations of 7 samples)

Figure 5.8: Computer simulation of relative sample density of EPI-sampling

Chapter 9 includes more detail relating to the development of the sampling simulator. It also contains the description of a mathematical optimisation approach to solve the same problem by using 'mathematical programming'.

Neither the EPI method nor its variants were considered for the testing of the *WaSH* indicators. The major reason is that none of the methods could deal with the high design effects found in surveys of access to water and sanitation. At the same time some effort were made to adapt and validate the EPI-sampling method as documented in Chapter 9.

Sequential sampling

Sequential sampling is an alternative to classical survey methods. It is used in manufacturing, agriculture, ecology and environmental sciences as well as public health. It is characterised by small sample sizes, which are often determined during the sampling process. The data collected from these non-fixed sample sizes may be analysed as individual BSU or as small batches of BSU. Data collection and analysis are combined into a single process called the "*sampling and classification plan*". Sequential sampling is primarily a *classification* or *decision-making* process rather than an *estimation* technique such applied in classical surveys. One of the many available sequential sampling techniques is Lot-Quality-Assurance-Sampling (LQAS) which is being used in public health.

Lot Quality Assurance Sampling

One of the limitations in implementing cluster surveys for prevalence is that they only give a general figure for the whole population and give no indication about the prevalence within the individual clusters surveyed. Lot Quality Assurance Sampling (LQAS) is an alternative form of sampling which gives some information on the different PSU referred to in this method as *lots*. LQAS originates from manufacturing where it was essential to keep manufacturing costs to a minimum (IMSP 2000) through limited testing and fast detection of production irregularities. LQAS is based on hypothesis-testing strategy rather than on an estimation strategy (Anker 1991). The population is divided into smaller but meaningful operational units, which form a mutual exclusive and exhaustive set of lots (Hoshaw-Woodard 2001). A minimal sample size is calculated, not to establish the prevalence but to determine how likely a particular prevalence is present (or not) in each lot. On the basis of this each lot is accepted or rejected. Since LQAS can also become a special case of stratified sampling in which random samples are taken in each lot, the sample results for all lots can be combined to attain a population estimate (MEASURE 1998). For each lot the null hypothesis H_0 is that the measured prevalence P is equal or higher than a set value P_0, as shown in Equation 5.27.

$$H_0 : P \geq P_0$$
$$H_a : P < P_0$$

H_0 is the null hypothesis in which the
H_a is the alternative hypothesis
P the true proportion
P_0 the critical value at which to accept or reject H_0
(E.g. H_0: Lot has $(P) \geq 80\%(P_0)$ access to sanitation.)

Equation 5.27: Null hypothesis for LQAS

This leads to a decision process as reveals Table 5.8 where the columns show the true values and the rows the measured values.

	Access to sanitation by actual population: Yes	Access to sanitation by actual population: No
Fail to reject H_0 (Do not intervene)	Test recognises high access level **1-α** *sensitivity*	Deprive lot of intervention **β** *false positives*
Reject H_0 (Increase access level)	Wrongly targeted resources **α** *false negatives*	Test recognises low access level **1-β** *specificity*

Adapted from (Lemeshow 1991)

Table 5.8: Consequences of hypothesis testing in LQAS

In Table 5.8 there are two errors possible, the false negatives (α) and the false positives (β) as illustrated in Figure 5.9. False negatives would indicate people not having access while in reality they have.

By rejecting the null hypothesis (H_0) in those lots a targeted intervention based on this outcome could lead to resources being used less efficient or even wasted.

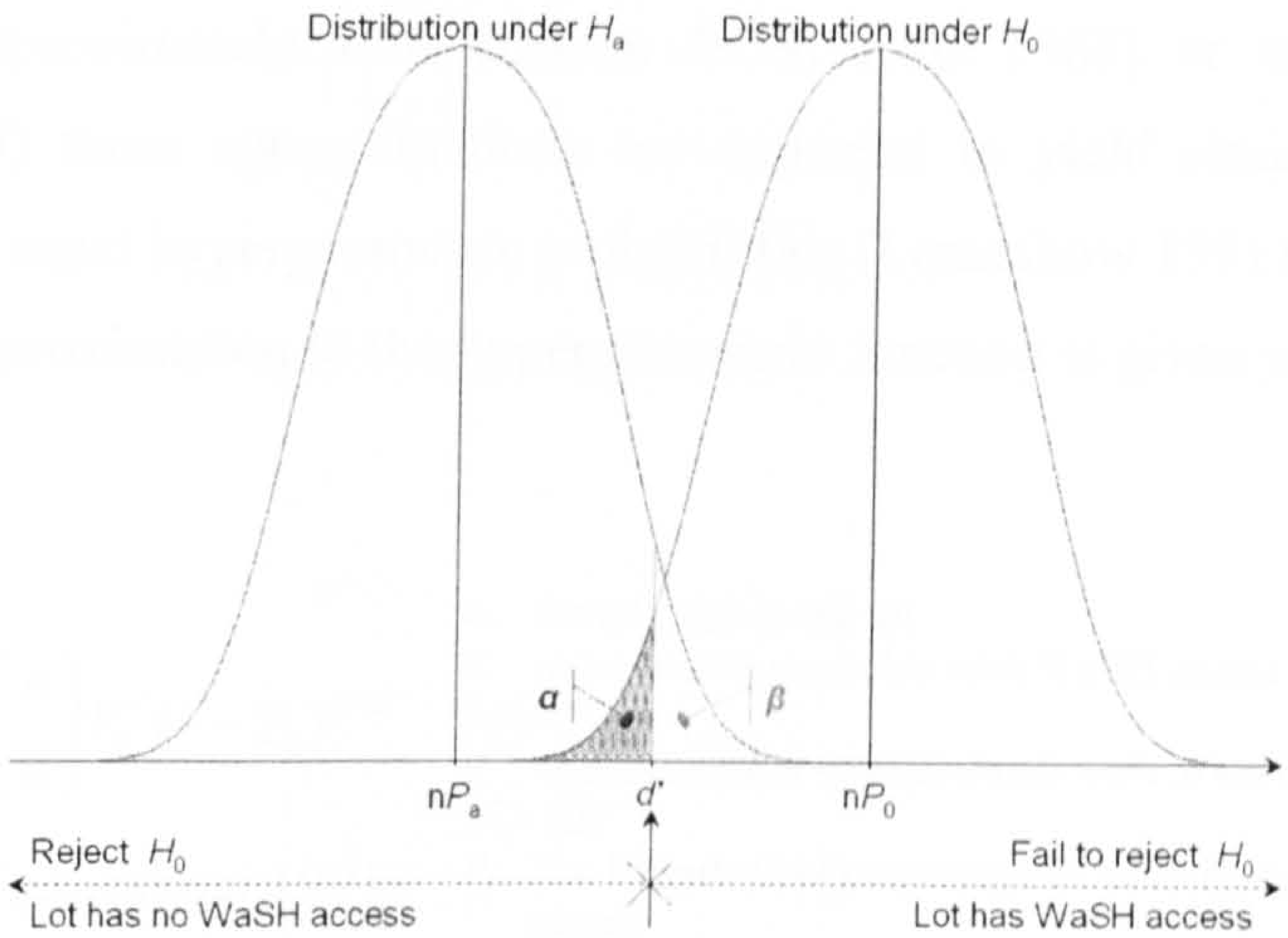


Figure 5.9: Distribution of H_a and H_0 indicating probabilities α and β

This error could be considered from a funding perspective the worst type of error. False positives are for target populations the worst type of error, as they could deprive people from access by presenting an over-optimistic picture of real conditions.

The **hypergeometric distribution** in Equation 5.28 represents the probability of observing d households with WaSH access in a sample size of n from a population of N households in which NP_0 are hypothesized to have WaSH access.

$$f(d \leq d^*) = \sum_{d=0}^{d^*} \frac{\binom{NP_0}{d}\binom{N(1-P_0)}{n-d}}{\binom{N}{n}}$$

(Lemeshow 1991)

N population size in the lot.
n sample size in the lot
d # of households with WaSH access in a sample of n households
d^* critical # of households with WaSH access in a sample of n HH
P_0 the hypothetical percentage of households having WaSH access
$f(\ldots)$ probability function

Equation 5.28: Hypergeometric distribution representing the probability of WaSH access

An important feature of the hypergeometric distribution is that it accounts for the probability of selecting a household with WaSH access without replacement (Liebermann 1961). If the probability calculated with $f(d \leq d^*)$ is small relative to α, then it is possible to conclude that the proportion of households in the sample of n households of that particular lot is unlikely to be as high as P_0. It could then be classified as a 'low' access area.

The hypergeometric function is complex and approximations are often used in an attempt to simplify calculations and represent the information in a more intuitive manner (Lemeshow 1991). When the ratio of the sample size n to the population N is smaller than approximately 10% (Dodge 1959; Kotz 1983) or when N is large (Brownlee 1965) these approximations are expected to yield similar probabilities compared to the exact hypergeometric probabilities (Lemeshow 1991).

The binomial approximation to the hypergeometric function is given in Equation 5.29.

$$f(d \le d^*) = \sum_{d=0}^{d^*} \binom{n}{d} P_0^d (1 - P_0)^{n-d}$$

(Lemeshow 1991)

n sample size in the lot
d number of households with WaSH access in a sample of n households
d^* critical number of households with WaSH access in a sample of n HH
P_0 The hypothetical percentage of households having WaSH access
$f(...)$ probability function

Equation 5.29: Binomial approximation to the hypergeometric function

This approximation can be used to represent the probability of finding d households having access to WaSH out of a sample size of n households (Lemeshow 1991). This assumes that the probability of each household having access to WaSH is constant for each consecutive household which will be for all practical purposes be true when N is large compared to n (Lemeshow 1991). This restriction is important as the approximation in Equation 5.29 does, contrary to Equation 5.30, not take account of the population size N as N does not figure in Equation 5.29.

The **normal approximation to the hypergeometric** gives normal distribution with a mean and a standard deviation as shown in Equation 5.30

$$mean(d) = nP_0$$

$$\sigma = \sqrt{nP_0(1 - P_0)\left(\frac{N-n}{N-1}\right)}$$

Adapted from: (Lemeshow 1991)

d # households with WaSH access in a sample of n households
n sample size in the lot
N population size in the lot
P_0 The hypothetical percentage of households having WaSH access
σ Standard Deviation (SD)

Equation 5.30: Normal approximation to the hypergeometric function

Equation 5.31 determines the number of standard deviations value d is away from the expected value nP_0. The value z obtained with Equation 5.31 can be used to determine the probability of the observed scenario relative to the null hypothesis by using a normal probability table.

$$z = \frac{d - nP_0}{\sigma} = \frac{d - nP_0}{\sqrt{nP_0(1-P_0)\left(\frac{N-n}{N-1}\right)}}$$

z reliability coefficient (one tailed see Figure 5.9)
d Mean of d over all lots
n sample size in the lot
N population size in the lot
P_0 The hypothetical percentage of households having WaSH access
σ Standard Deviation

Equation 5.31: Number of standard deviations d is away from the expected value nP_0

For each of the lots a set of n and d^* will have to be calculated. There are two ways to determine the samples size n and the critical value d^* for each lot. The first is by setting the sample size n that can be tested per lot as shown in Equation 5.32 and rewrite the same equation in function of n. The values obtained will seldom be whole figures so the result will have to be rounded depending on the type of error accepted. In our case it would usually be rounding up.

$$\begin{aligned} d^* &= nP_0 - z_{1-\alpha}\sigma \\ &= nP_0 - z_{1-\alpha}\sqrt{nP_0(1-P_0)\left(\frac{N-n}{N-1}\right)} \end{aligned}$$

$z_{1-\alpha}$ reliability coefficient for a probability equal to 1-α
d Mean of d over all lots
n sample size in the lot
N population size in the lot
P_0 The hypothetical percentage of households having WaSH access
σ Standard Deviation

Equation 5.32: Determining the critical value for d^* on the basis of a chosen sample size n.

Rewriting the results in a quadratic formula as shown below would allow determining the required sample size.

$$\begin{aligned} d^* &= nP_0 - z_{1-\alpha}\sigma \\ &= nP_0 - z_{1-\alpha}\sqrt{nP_0(1-P_0)\left(\frac{N-n}{N-1}\right)} \quad \text{For small sampling proportions} \\ &= nP_0 - z_{1-\alpha}\sqrt{nP_0(1-P_0)} \qquad (n \ll N) \Rightarrow \left(\frac{N-n}{N-1}\right) \cong 1 \end{aligned}$$

$$\left(nP_0 - d^*\right)^2 = z_{1-\alpha}^2 P_0(1-P_0)n$$

$$P_0^2 n^2 + d^{*2} - 2P_0 d^* n = z_{1-\alpha}^2 P_0(1-P_0)n$$

$$
\begin{aligned}
0 &= P_0^2 n^2 - \left(z_{1-\alpha}^2 P_0(1-P_0) + 2P_0 d^*\right)n + d^{*2} \\
&= an^2 + bn + c \quad \text{with} \\
a &= P_0^2 \\
b &= -(z_{1-\alpha}^2 P_0(1-P_0) + 2P_0 d^*) \\
c &= -d^{*2}
\end{aligned}
$$

$$
n = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \text{ if only absolute values for } z \text{ are used} \Rightarrow n = \frac{-b + \sqrt{b^2 - 4ac}}{2a}
$$

$$
n = \frac{z_{1-\alpha}^2 P_0(1-P_0) + 2P_0 d^* + \sqrt{\left(z_{1-\alpha}^2 P_0(1-P_0) + 2P_0 d^*\right)^2 + 4P_0^2 d^{*2}}}{2P_0^2}
$$

Equation 5.33: Sample size calculation for LQAS sampling based on the critical value d^*

Another approach to determining the sample size n and d^* takes in account the two errors α and β as shown in Table 5.8 and Figure 5.9. This results in two formulas of d^* as shown below. As $P_a < P_0$. The only difference in both formulas is the sign, as they represent the calculation of a lower limit (for P_0) and an upper limit (for P_a) of the one ended confidence interval.

$$
d^* = nP_0 - z_{1-\alpha}\sqrt{nP_0(1-P_0)\left(\frac{N-n}{N-1}\right)} \text{ lower limit } P_0
$$

$$
d^* = nP_a + z_{1-b}\sqrt{nP_a(1-P_a)\left(\frac{N-n}{N-1}\right)} \text{ upper limit } P_a
$$

$$
\begin{aligned}
nP_0 - z_{1-\alpha}\sqrt{nP_0(1-P_0)} &= nP_a + z_{1-b}\sqrt{nP_a(1-P_a)} \\
nP_0 - nP_a &= z_{1-b}\sqrt{nP_a(1-P_a)} + z_{1-\alpha}\sqrt{nP_0(1-P_0)} \\
n^2(P_0 - P_a)^2 &= \left(z_{1-b}\sqrt{nP_a(1-P_a)} + z_{1-\alpha}\sqrt{nP_0(1-P_0)}\right)^2 \\
&= n\left(z_{1-b}\sqrt{P_a(1-P_a)} + z_{1-\alpha}\sqrt{P_0(1-P_0)}\right)^2 \\
n &= \left(\frac{z_{1-b}\sqrt{P_a(1-P_a)} + z_{1-\alpha}\sqrt{P_0(1-P_0)}}{P_0 - P_a}\right)^2
\end{aligned}
$$

Equation 5.34: Sample size calculation taking account the size of errors α and β

The value for d^* can then be determined by either of the two formulae above.

While there are clear advantages in pinpointing the location of geographical lots that are under or over a certain threshold level of access, the method requires a lot of information and calculation. This makes it more suitable in areas where regular monitoring is considered. As the sample size n has to be calculated as a function of the sample size N in each lot the sample is self-weighted and the sample can be treated as a stratified sample not requiring any weighting.

Singh et al. (1996) compared the coverage results using LQAS with those obtained with the standard EPI method for vaccination coverage. They found no statistically significant difference between both methods. The study also compared the cost and time required for data collection. The LQA sampling took three times more time and cost 60% more in comparison with EPI. However, they also stated that these costs could be reduced if the data collection system were executed entirely by local staff.

It seems odd however for agencies to consider a pseudo-probability sample such as EPI-sampling for coverage figures when enough detailed information is available to consider LQAS. This indicates how mainstream EPI has become due to its popularity and is erroneously seen as a genuine alternative to probability sampling (Stoeckel 1997). LQAS can use more than one threshold value to classify its lots.

For example, the two stage sampling version of LQAS allows for a partial sample size n_1 to be taken and a comparison of d_1 with d_1^*. If a decision is possible based on a sample size n_1 no further samples are taking. If no decision is possible the sample size is increased with n_2 to obtain the same sample size $n = n_1 + n_2$ and $d = d_1 + d_2$ is compared with d^* as before. Decision can be taken based on a smaller sample which allows the overall sample size to be reduced. As the sample size in each lot can vary it becomes increasingly complex to obtain an overall estimate for the measure of interest. Overall estimates are in this thesis the primary goal for data collection and as such, this type of multiple stage sequential sampling will not be considered.

By pointing out the lots that might be under a certain threshold level[4], the method deals with one of the major frustrations people often face with summative data collection in cluster surveys.

The methods limitations include the need for an accurate population census as a sampling frame and the requirement that BSUs are selected randomly (Lanata 1990). This means that the sampling method still requires detailed sample frames for each lot. The amount of detail required in the sample frames could only be justified if sample frames are kept up to date and data is collected at regular intervals, for example to be used for programme implementation. It does not seem a valid option for independent progress monitoring.

[4] Be it with significant confidence intervals

5.5.2 Other sampling approaches of interest

There have been various 'improvements' suggested to the EPI method (Bennett 1991; El Bindari-Hammad 1989) involving changes to the second stage sampling such as taking every third or fifth household (Bennett 1994). Some variations suggest replacement of the EPI 'random walk' by area sampling. In '*compact segment sampling*' the PSUs selected in the first stage are divided up into smaller segments and all households are included in the sample (Milligan 2004; Turner 1996). Some sampling methods such as *centric systematic area sampling* have gone even further in area sampling (Myatt 2006; Myatt 2005). They obtain an even and exhaustive special sample by stratifying an area into approximately 30 quadrats by overlaying a grid over the geographical area of interest, as shown in Figure 5.10.

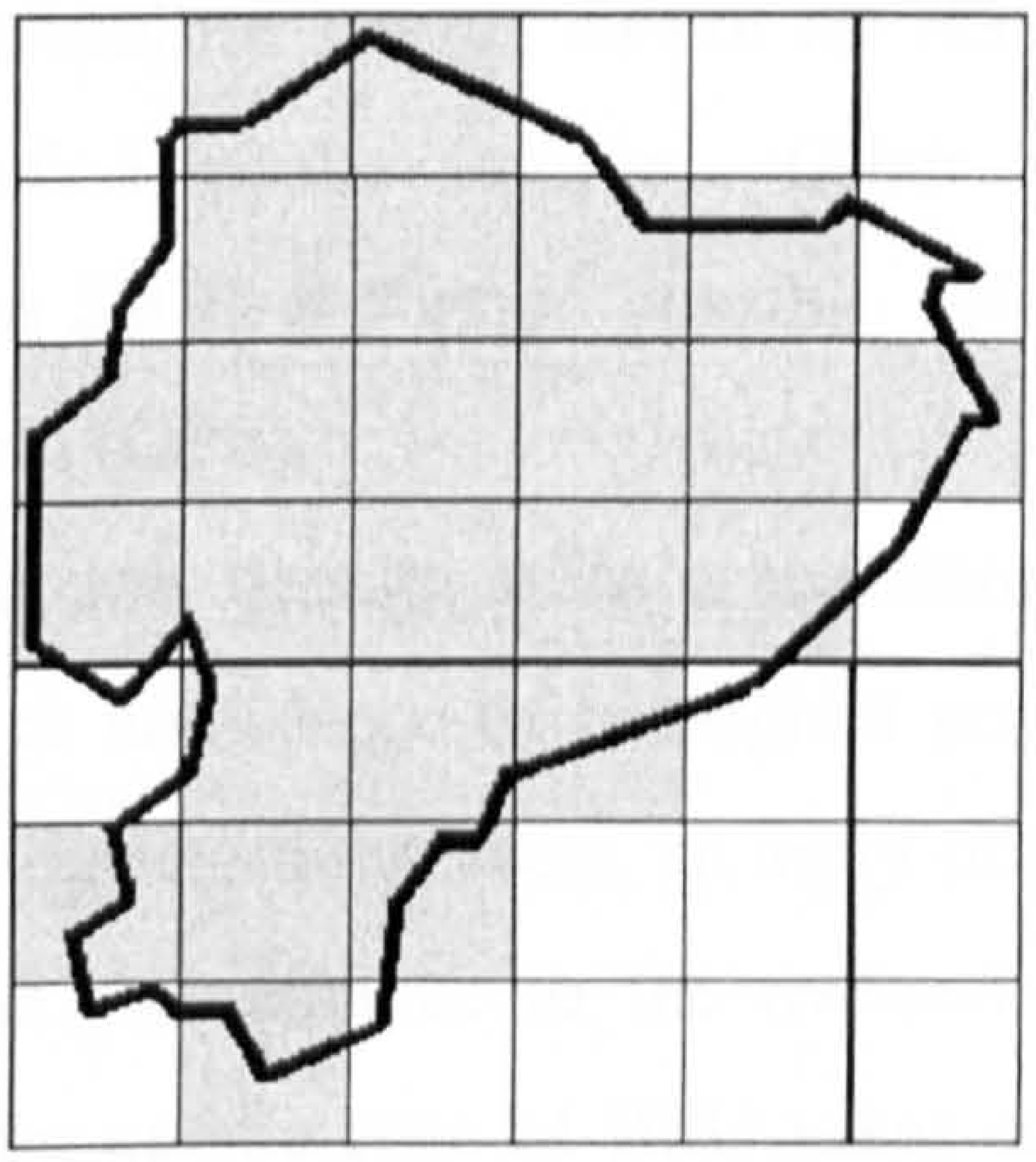


Figure 5.10: Centric systematic area sampling grid overlay

The communities closest to the centre of each quadrat are sampled. The number of communities and their sizes determines the number of communities sampled in each quadrat. This has been tested in nutritional surveys in which the collected data is used in screening for malnutrition. While the survey is able to give more information over

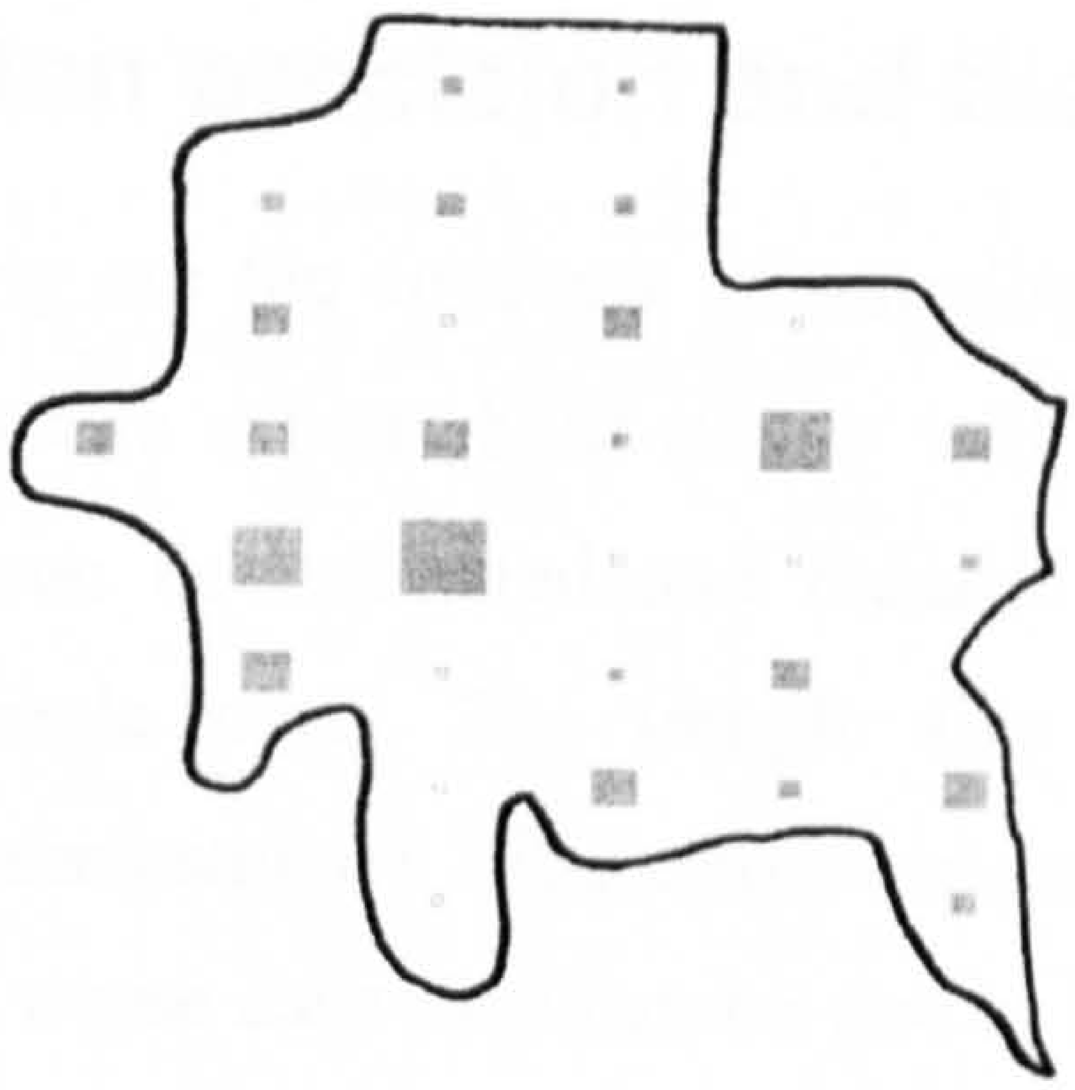


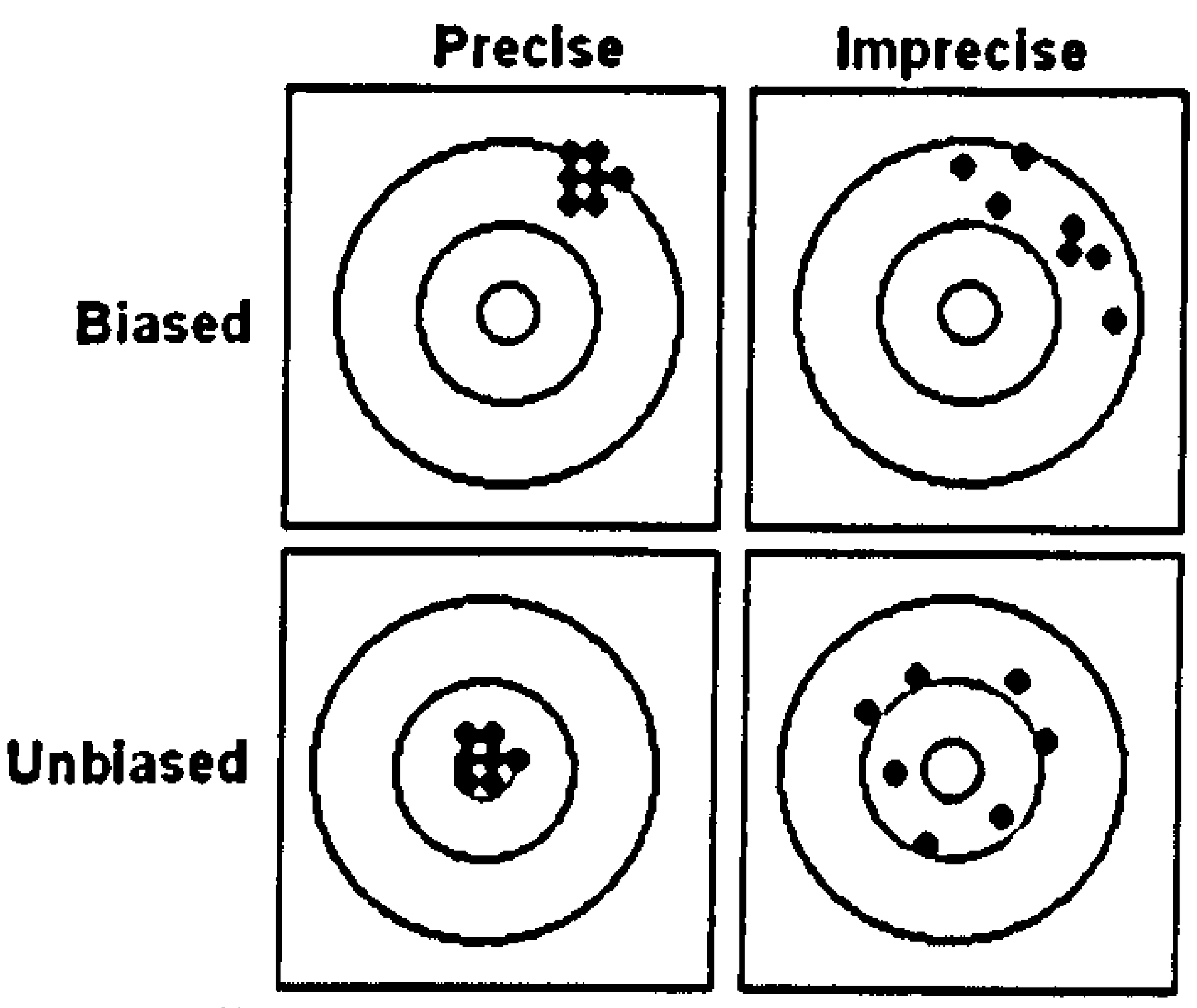
Figure 5.11: Coverage of malnourished children attending a nutritional centre per quadrat

the spatial spread of the variable of interest as shown in Figure 5.11, the method cannot be considered a probability sample as not all BSU have an equal or known probability of being included in the sample. Other methods such as 'random geographical points' (Mann 2002) are made possible using new technology such as the global positioning system (GPS).

Another method suitable for low density areas is the *distance sampling* method used for estimating the density or abundance of biological populations. It is based on a standardised survey along a series of transects, an array of points or random locations. For each closest household the distance to the transect or point is measured. A *detection function* depending on the type of BSU takes account of the likelihood of detecting another BSU in function of the distance (hence *distance method*). This method not only allows measurement of variables of interest where there is no sample frame but also permits estimates of total population which no other method without a sample frame has been able to do (See Chapter 9). While sampling strategies in ecology show great promise for household surveys, they need further development and testing, as do any of the methods suggested in this section, to determine their suitability for household surreys. Some methods require a solid scientific footing; others need to be properly tested before being applied for household surveys. This is the main reason why they are not considered for the testing the *WaSH* survey methodology. While none of these methods was considered for field testing, some of research done on these methods during this project is presented in Chapter 9.

5.6 Data collection precision and bias

Directly related to sampling are the concepts of sampling and non-sampling errors. Any form of data collection in a household survey will entail errors. Some errors such as sampling errors can be estimated and reduced by selecting an adequate sampling scheme and sample size. The sample size and sample strategy will determine the precision of the estimate. The errors can be related to how precise the measurement is, but in the worse case they can be due to bias. The relation between precise and biased estimates is best illustrated with an example from target practice (see Figure 5.12)



Picture source: http://www.stats.gla.ac.uk/steps/glossary/sampling.html#bias

Figure 5.12: Bias and precision in target practice

As shown above, a biased outcome in values deviates by a systematic error from the true result and should be avoided. Biased samples are often due to the selection of a sample which is not representative of the sample or an inference outside the initial population. As there is often no gold standard to compare the results obtained, it is rarely possible to determine whether samples are biased.

Sampling errors.

Sampling errors are inevitable because samples can differ from the populations they aim to represent. Therefore, sample survey results can only be considered as estimates of the measure of interest. Sampling error estimates can, in principle, only be calculated on probability samples. Errors of precision are often related to *sample size* and the *sample plan* used in the survey. The aim of the sampling process, and particularly the randomisation in that process, is to minimise the differences between a sample and the population it represents. These differences should only be due to random chance. When differences arise for reasons other than chance, bias may have been introduced to the sample. Administrative convenience, resulting in non-probability sampling techniques, is usually a major source of bias.

The division between sampling and non-sampling errors is not always clear. The differences are mainly related to how narrow the sampling process is defined. Errors such as coverage errors could be seen as a sample error. They occur when there is an omission, duplication, or wrongful inclusion of the units in the population or sample, often caused by defects in the survey frame: inaccuracy, incompleteness, duplication, inadequacy, and obsolescence. Because the error is not due to the sampling process (sample size and sample plan), coverage errors are often referred to as non-sampling errors and discussed as such in more detail in the next chapter.

Non-sampling errors

Although a lot of attention and effort is put on estimating sampling errors, non-sampling errors are often bigger than sampling errors (Vaessen 2005). This is the case if insufficient attention is paid to the design and testing of data collection tools, and the training and recruitment of field and data processing staff. Thus the control of non-sampling errors should be a major objective in every survey. Non-sampling is covered in the next chapter on practical implementation.

5.7 Selected sampling strategy

This chapter looked at various issues regarding sampling and determined the ideal number of clusters and *take* size for the *WaSH* filed trial when a sample frame is available. The chapter looked also at alternative sampling methods for use when sample frames were not available, but could not yet find any suitable and proven method. Efforts to find a suitable method not requiring a detailed sample frame ran parallel with the field trials of the survey method and are further discussed in Chapter 9.

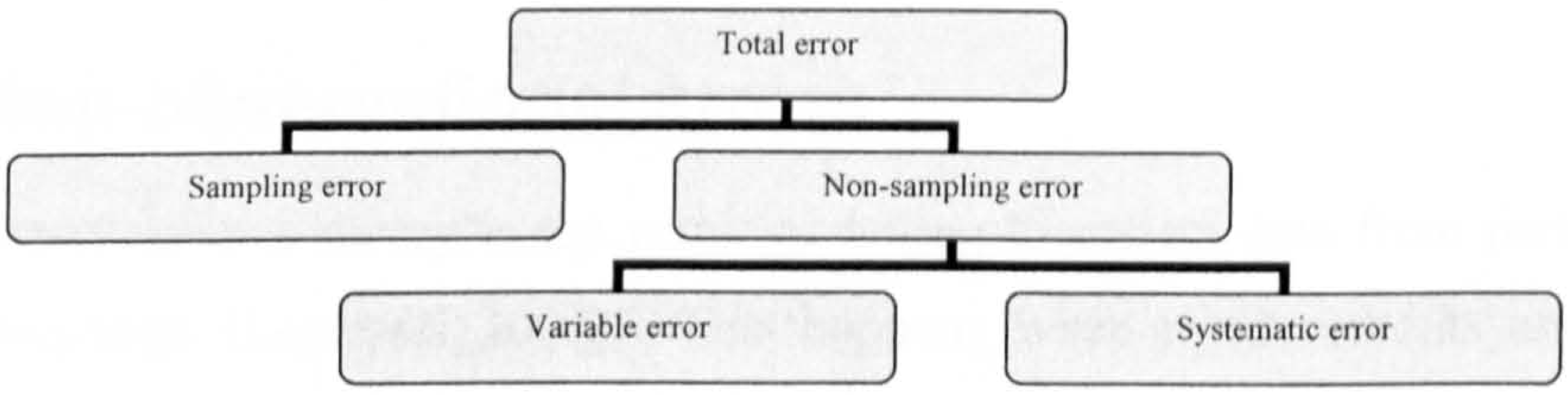
The sample plan for field-testing is a two stage 32 cluster x 32 BSU cluster design resulting in a sample size of 1024. In practice this ideal sample size must be increased by the expected non-response ratio. The first stage sampling selects 32 PSU with a probability proportionate to the size of each PSU. The measure of size used will be the estimated number of households within each PSU. The second stage sampling will use simple random sampling (SRS) which makes the design self-weighted or EPSeN so no sample weights have to be calculated. The sampling errors of such a design are expected to fall within a ±10% point confidence interval. However while sampling errors are important, non-sampling errors are considered to be larger than the sampling errors and will be discussed in next chapter.

CHAPTER 6 PRACTICAL IMPLEMENTATION

Chapter 5 discussed the selection of a representative probability sample of households and sampling errors arising from this selection process. This resulted in the choice of the sampling plan and sample size as mentioned in section 5.7, which will also influence how data has to be analysed as shown in Chapter 7. Aside from sampling errors associated with the process of selecting households, a survey is subject to a wide variety of non-sampling errors. As mentioned in the previous chapter the line between sampling and non-sampling errors is not always clear. This chapter will look at the most common errors, which are related neither to the chosen sample plan nor to the sample size determined in the last chapter. Non-sampling errors are mainly related to inaccuracies during practical implementation. Non-sampling errors are likely to be bigger than sampling errors in field survey (Kendall 1994; Lohr 1999; Vaessen 2005). This is, according to Vaessen (2005), particularly the case if insufficient attention is paid to training and recruitment of field and data processing staff. Thus, the control of non-sampling errors should be a major objective in every survey. This chapter will discuss some of the issues relating to implementation of surveys and their relationship to non-sampling errors.

6.1 Non-sampling error

The total household survey error consists of a sampling and a non-sampling error as shown in Figure 6.1.



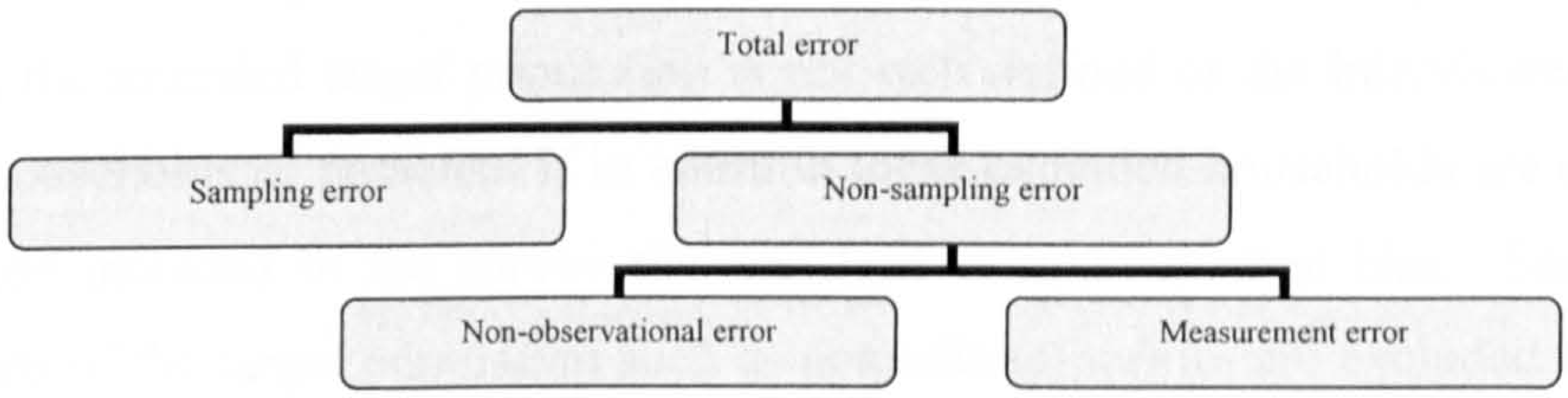
From (Banda 2003)

Figure 6.1: Total error in field survey

There are two groups of non-sampling errors: random errors, systematic errors (Banda 2003). *Random errors* are unpredictable errors resulting from estimation. Since they are random, they tend to cancel out, particularly if a large enough sample is used (StatCan 1999), though they do reduce the precision of the survey. Random errors can become a problem in surveys that aim to use relativly small sample sizes, such as the *WaSH* survey methodology. When these errors take effect, they lead to an increased variability in the characteristic of interest.

Systematic errors are errors that tend to introduce bias into the sample and often accumulate over the entire sample.

Non-sampling errors are extremely difficult, if not impossible, to measure. Since random errors have the tendency to cancel out, systematic errors are the principal cause for concern. Unlike random errors, systematic errors cannot be controlled by increasing the sample size. Non-sampling errors can occur because of problems in coverage, measurement, non-response, data processing and even in estimation and analysis of the data (Lepkoski 2005). Non-sampling errors can also be divided in measurement errors and non-observational errors, as shown in Figure 6.2.



Adapted from (Banda 2003)

Figure 6.2: Total error in field survey including measurement error

Some measurement errors relate to the processing of the data and its analysis. Though they fall under measurement errors, they will be covered separately in section 6.4 on *processing errors*.

6.2 Non-observational errors

Non-observation in a survey is the result of failing to collect data from parts of the target population (Lepkoski 2005). This happens when measurements are not or cannot be made of some households. This non-observation can be complete non-observation when no measurements at all is collected from the household, or partial when only part of the desired data is collected from the household. The two sources of non-observational errors are non-coverage and non-response (Lepkoski 2005).

6.2.1 Non-coverage errors

Coverage errors are caused by defects in the survey frame: inaccuracy, incompleteness, duplication, inadequacy and obsolescence. Non-coverage or under-coverage (StatCan 1999) errors occurs when households in the population have no chance of being selected for the survey (Lepkoski 2005). Over-coverage is also possible when households not meant to be part of the target population are included into the survey. In household surveys, over-coverage is less likely. One obvious source of non-coverage can be the sampling process as covered in Chapter 5. When sections of the intended target population are not incorporated into the sample frame this can cause non-coverage errors, as these households have no chance of being included in the sample. This is possible for structural reasons (e.g. not keeping sampling sample frames up to date) or deliberate reasons (e.g. exclusion of minority groups). Such exclusions are also possible when households include live-in caretakers of buildings which in the sample frame are not considered potential living quarters, the intended target population is not well defined or the interviewer misses several households or persons. If in addition these excluded households are different from those included in the survey this can lead to non-coverage bias. Sometimes small parts of the target population such as nomadic minorities are excluded from the survey for cost, practical and security reasons (ORC Macro 1996). Coverage errors can also crop up in reporting if the readers are explicitly or implicitly led to believe that results cover a wider population that was targeted in the survey (ORC Macro 1996) although some refer to this as representation errors (Tucker 2002). The possible bias due to analysing data collected from the population actually covered instead of the data collected from the desired target population is described in Equation 6.1.

$$B(\bar{y}_c) = (N_{nc} / N)(\bar{Y}_c - \bar{Y}_{nc})$$

(Lepkoski 2005,p.156)

$B(\ldots)$	Bias of the measured outcome
$\bar{y}_c$	Measured mean of the covered households
N	Number of households targeted in the survey
N_{nc}	Number of households not covered in the survey
$\bar{Y}_c$	Mean of the measure in the covered households
$\bar{Y}_{nc}$	Mean of the measure in the non-covered households

Equation 6.1: Function expression for the bias due to non-coverage

This formulation illustrates that either (N_{nc}/N) the proportion of the people not covered in the survey, $(\overline{Y}_c - \overline{Y}_{nc})$ the difference between the measure of interest in the covered and non-covered populations, or better both factors, should be kept as small as possible. There are according to Lepkoski (2005) four ways of handling non-coverage errors:

- *Reduce* the level of non-coverage error in the household survey;
- *Measure* the extent of the non-coverage error and report it;
- *Compensate* for non-coverage error through statistical adjustment;
- *Report* non-coverage issues as fully as possible in the survey report.

Reducing the level of non-coverage error in the household survey is usually attempted through the use of multiple independent sample frames or through methods to improve listing processes. Unavailability and lack of accuracy of existing sampling lists in low-income countries is a problem, as discussed in Chapter 4. Creating or improving sample frames requires many resources which are usually unavailable for small specific surveys such as the *WaSH* survey. *WaSH* is for that reason restricted to the best sample frame available at the time of the survey.

Some procedures allow one to *measure* to what extent households are included in the sample frame. These could consist in listing, in a set way, a number of households near the assessed household and checking if they are all listed in the sample frame. These methods are limited to assessing coverage of areas in which some households are included in the sample but do not estimate coverage of areas completely ignored in the sample frame. Measuring the extent of non-coverage through this method, which is analogous to the capture, recapture methods used in environmental sciences (Buckland 1993) was originally considered for the *WaSH* field trials but had to be abandoned due to the resource constraints discussed in Chapter 7.

A common way of *compensating* for non-coverage is to assess indicators measured in the survey and contrast them with comparable measures in other surveys. This approach would allow a skilled statistician to calculate weight corrections for each sample to compensate for under-covered sections of the population in the survey.

A more independent but more expensive measurement of non-coverage is the use of dual sampling (Marks 1978). Independent surveys match cases between two surveys and check how likely it is that certain section of the population are not covered.

These methods are also closely related to "*capture and recapture sampling*" used in environmental studies (Buckland 1993; Thomas 2002). These more elaborate approaches allow one not only to determine the level of non-coverage but also the possible degree of bias.

Compensation for non-coverage requires technical skills which are far beyond those expected of the people likely to implement the *WaSH* survey method. For that reason, compensation for non-coverage will not be considered in this thesis.

Reporting possible non-coverge bias is the last method of handling non-coverage bias. According to Lepkoski (2005) it is the most suitable method for simple and small surveys. It requires reflection on which households should ideally be covered in the survey, but might be left out of during the sampling process. The method does not require particular statistical skills, but just the ability to document possible non-coverage and reflect on the consequences and possible bias this would entail. Reporting, rather than compensating, is considered the best approach for small surveys such as the *WaSH* survey methodology.

Non-response errors

Non-response errors occur when households selected for the survey do not participate in the survey or do not provide all the information requested (Lepkoski 2005). While non-response is a separate problem from non-coverage, there are parallels with regards to dealing with it. While for non-coverage issues, survey designers almost never know anything other than the location and the general characteristics of the non-covered portion of the population, in non-response problems, they know at least the frame information for non-respondents. Non-response is common in household surveys, and is likely to contribute to the bias of the survey estimates (Lepkoski 2005). Non-response can take place at each level of the survey when, for example, an entire PSU cannot be surveyed due to insecurity or a lacking necessary authorisations. More frequently, non-response takes place at the household level when households cannot or are not willing to give part or any of the information required. One example is *language exclusion* (Lepkoski 2005) in which none of the languages in which the survey is provided would allow some of the required data to be collected. Language problems can be solved using on the spot translations by the interviewer or interactive use of a translator. Many surveys such as MICS (UNICEF 1999) and DHS (ORC Macro 2002) reject this practice due to concerns about whether the translation is correct and consistent across households. In DHS surveys, any language group that constitutes 10% or more of the sample should have its own translated questionnaire (Vaessen 2005). Households that cannot provide answers can be classified as non-responding units. Some survey organisations exclude non-response due to language from the survey, so that these households become non-covered rather than non-responding (Seligson 1994). There are no widely accepted rules for making such a classification (Lepkoski 2005). Non-response may also occur when the ideal respondent (in the case of the *WaSH* survey "*the women of the house*") is not available. However, as in other surveys the *WaSH* survey allows proxy reporting on survey questions. In view of the lack of widely agreed practice, it is important that survey organisations state clearly in survey reports how such cases have been handled in a given survey (Lepkoski 2005).

More research has been devoted to the problem of non-response in household surveys than to non-coverage (Groves 1998; Lessler 1992). This is because non-coverage is less visible than non-response, It is therefore easier to quantify non-response and collect information on non-respondents. There is a presumption in high-income countries that non-coverage is less important than non-response because the non-coverage rate is lower than the non-response-rate. The opposite is more likely for developing countries where non-response rates are lower and the non-coverage rate much higher than in developed countries (Lepkoski 2005).

Similar to non-coverage, the extent of the bias due to non-response can be formulated as in Equation 6.2. This shows that the risk of bias increases with the number of non-responding households and the extent to which the non-respondents are different from respondents with respects to the measure of interest.

$$B(\bar{y}_r) = (N_{nr}/N)(\bar{Y}_r - \bar{Y}_{nr})$$

(Lepkoski 2005,p.162)

$B(\ldots)$	Bias of the measured outcome
$\bar{y}_r$	Measured mean of the responding households
N	Number of households targeted in the survey
N_{nr}	Number of non-responding households in the survey
$\bar{Y}_r$	Mean of the measure in the responding households
$\bar{Y}_{nr}$	Mean of the measure in the non-responding households

Equation 6.2: Function expression for the bias due to non-response

Non-response rate can be calculated by a formula adapted from the American Association of Public Opinion Research (AAPOR 2000) as shown in Equation 6.3.

$$NRR = \frac{Nobody + Uncooperative}{Nobody + Uncooperative + Interviews}$$

NRR Non-response rate
Nobody Number of households where nobody could be found to collect data from
Uncooperative Number of households who did not want to take part in the survey
Interviewed Number of households who did a whole or a partial interview

Adapted from (AAPOR 2000)

Equation 6.3: Calculation of the non-response rate

This simplified formula was too crude for the complex reality of the field, as will be discussed in Chapter 8. The difference between non-coverage and non-reply also proved far from being straightforward (Chapter 8). Reducing household non-response is in many circumstances achieved through *ad hoc* methods (Lepkoski 2005,p164). When households are not available repeat visits, or *call-backs,* are in most surveys a standard procedure to reduce non-response. Interviewers try to establish when the household is more likely to be available and make several attempts at an interview. When a maximum agreed number of *call-backs* have been unsuccessful the household will be classified as a non-response. Training people in the difficult task of refusal conversation can reduce the rate of refusal to participate in the survey. There is no empirical evidence to suggest which method, (call-back, early warning of households or other) is any better at improving the response rate (Lepkoski 2005). In the *WaSH* surveys, which includes observations, it is felt that people might influence the outcome of the observation if warned in advance. Call-back also restricts revisits to non-responding households, while early warning requires all the households to be visited at least once before data collection. Call-back is expected to involve less impact on time and other resources to implement the survey. In high-income countries incentives to participate in a survey are becoming widespread (Kulka 1995). In low-income countries and countries in transition they are controversial, and many countries discourage this approach (Lepkoski 2005). For the *WaSH* survey no incentives are considered, neither to the surveyors[1] or the surveyed. *WaSH* recommends to feedback (partial) survey results at the end of the data collection to the household included in the sample as well as the relevant authorities of the survey area. The alternative, as suggested by the relative failure of

[1] Surveyors usually get an allowance which is unrelated to the number of successful or unsuccessful interviews.

other options to improve non-response, is by proper training of the survey's staff. Requirements for survey-staff training are listed towards the end of this chapter.

6.3 Measurement errors

Measurement errors in this section are defined as the differences between the data recorded by the interviewer and the 'true' value of interest. Biemer et.al. (1991) attributes these errors to four aspects of the survey (adapted below):

- *Questionnaire*: the questionnaire design's effect, its visual layout, the topics it covers, and how the questions are worded;
- *Data collection method*: questions, observations and demonstrations can result in different outcomes for the same 'question';
- *Interviewer*: the effect the interviewer may have on responses to the same question. The interviewer may introduce error in survey responses by not reading the items as intended, by probing inappropriately when handling an inadequate response, or by adding other information that may confuse or mislead the respondent.
- *Respondent*: because of their different experiences, knowledge and attitudes, may interpret the meaning of questionnaire items differently. The respondent might also react differently on questions to which he or she does not know the answer, answer in a way which they think might please the interviewer or in a manner that they think might benefit them in future.

Questionnaire effects

Over the last decades there has been increased research into questionnaire effects (Bradburn 1991; Schwarz 1997; Sirken 1999; Sudman 1996). Measurement errors can give rise to both bias and accuracy. Measurement or response bias occurs when there is systematic error between the measurement and the true value. The different aspects to questionnaire effects are (Kasprzyk 2005):

- Specification problems
- Question wording
- Length of question
- Length of questionnaire
- Order of questions
- Response categories
- Open and closed formats
- Questionnaire format

These aspects were covered directly and indirectly in Chapter 3.

Data collection method

The *WaSH* method has various data collection methods as discussed in Chapter 3. The main method is a face-to-face interview in which an interviewer administers a questionnaire to an interviewee. In the *WaSH* methodology the paper and pen-based personal interview (PAPI) is preferred over computer-assisted personal interviewing (CAPI) as it requires less investment and can be more easily replicated. Technology assisted data collection has some advantages however, (Couper 1998) which are worth considering since such equipment is becoming more affordable. Advantages and disadvantages of this approach are discussed in Chapter 9.

6.3.1 Interview effects

An interviewer can influence how a respondent answers the survey questions. This may occur when the interviewer is too friendly or aloof or prompts the respondent. To prevent this, interviewers must be trained to remain neutral throughout the interview. They must also pay close attention to the way they ask each question. If an interviewer changes the way a question is worded, it may influence the respondent's answer. The interviewer is seen as one of the principal sources of measurement error in data collected from structured face-to-face interviews (O'Muircheartaigh 1981). Literature offers little advice to help in the selection of interviewers. No particular age, gender, socio-economic status, or level of education results in more accurate reporting of survey data (Collins 1980; Groves 1989; Seymour 1977; Weiss 1968). According to Groves and Magilavy (1986) lowering the workload of the interviewer reduced the effect of interviewer variance but this requires additional interviewers which increases the survey cost. In annex F the number of surveyors required for data collection is calculated on their estimated workload.

To some extent training (discussed in section 6.6 page 228) and supervision can reduce interviewer error (Fowler 1991) but many believe that standardizing interview procedures is more important in reducing interviewer effect (Kasprzyk 2005). The surveyor and his interaction with the interviewee will have also an impact on the respondent-error as discussed below.

6.3.2 Respondent effect

Respondents can provide incorrect answers due to faulty recollections (recall period), tendencies to exaggerate or underplay events, and inclinations to give answers that appear more 'socially desirable' or less embarrassing in the case of sensitive information. Interviewees might want to give answers which they think will benefit them the most. This all fits a model by Hastie and Carlton (1980) who identify five sequential stages in the formation and provision of answers by survey respondents:

- *Encoding of information*, which involves the process of forming memories or retaining knowledge;
- *Comprehension of the survey question*, which involves knowledge of the questionnaire's words and phrases as well as the respondent's impression of the survey's purpose, the context and form of the question, and the interviewer's behaviour when asking questions;
- *Retrieval of information from the memory*, which involves the respondent's attempt to search her/his memory for relevant information;
- *Judgement of appropriate answer*, which involves the respondent's choice of the alternative responses to a question based on the information that was retrieved;
- *Communication of response*, which involves influences on accurate reporting after the respondent retrieved the relevant information, and the respondent's ability to articulate the response.

Hastie and Carlton's model demonstrates the importance of the way in which data are collected and the role an interviewer can play to reduce the respondent-effect. How data are collected is considered in Chapter 4 while the impact of the interviewer is covered in section 6.3.1. Therefore it will not be discussed further at this point.

6.4 Processing errors

The last group of errors are *processing errors*. They could be random or systematic and occur throughout the whole survey. They relate to how information is registered and processed. Process errors could be considered part of measurement errors but because they occur in a different part of the data collecting process they will be discussed separately in this section.

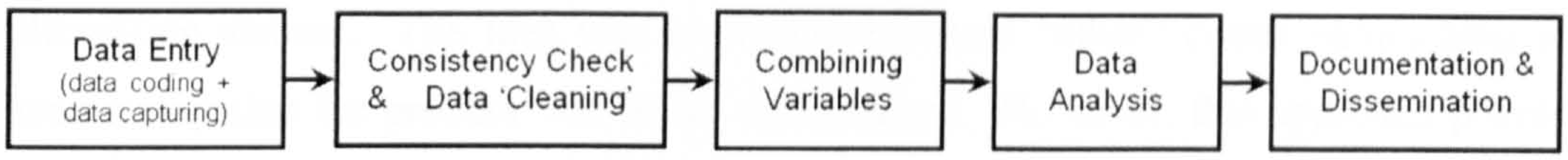


Figure 6.3: Essential blocks required for data processing in the *WaSH* survey methodology

The different steps expected in the *WaSH* data processing are highlighted in Figure 6.3. Each of these constituent parts is discussed in more detail below.

6.4.1 Data Entry

Data entry can be broken up into two steps in which the first, *data coding*, consists of preparing the paper-based data to a format more suitable for *data capturing*, the second step in which the coded data are transferred from paper to computer in a format suitable for data analysis.

Data coding

Data coding is the first step in which the collected data are transformed into a format that can be entered into a computer. In the *WaSH* survey this is done by the interviewer in the field and facilitated by the way the questionnaire is designed as shown in Figure 6.4.

S41	ທ່ານລ້າງມືຂອງທ່ານຢູ່ໃສ?			
Coding categories	Yes	No	Go To	Remarks
ອ້ອຍ ບໍ່ຄ່ອຍ/ບໍ່ເຄີຍ ລ້າງມື	1	3		ບໍ່ຄ່ອຍລ້າງ/ບໍ່ເຄີຍລ້າງ =>ໝາຍ Yes
ນອກເດີ່ນບ້ານ/ນອກຕອນດຶນ	5	7		
ຢູ່ນອກເຮືອນແຕ່ຢູ່ໃນບໍລິເວນບ້ານ	9	2		
ຢູ່ໃກ້ກັບຫ້ອງນ້ຳ	5	7		
ໃນຫ້ອງນ້ຳ	1	3		

Figure 6.4: Field coding of answers in *WaSH* survey in Thakhek, Laos

In the *WaSH* survey trial all data are coded in numbers on the survey forms to minimize the data coding required. In Figure 6.4 above "yes" and "no" have numeric values which can be easily coded. To minimize errors in imputation, "yes" and "no" do not have always the same value as illustrated above (Figure 6.4). However, such an approach does not eliminate data coding entirely. Categories such as "other" (see Figure 6.5) are, where possible, converted to a category suitable for analysis. Initially such coded value of "other" for example 96 was imputed into the data base with the alternative answer. The idea was to re-convert these "other" coded values later in such a way that the process was better documented. However, this approach proved excessively time-consuming as discussed later in Chapter 6 and so was quickly abandoned.

S16	ທ່ານມີການບຳບັດນ້ຳດື່ມທີ່ໄປຕັກມານັ້ນຫຼືບໍ່ກ່ອນທີ່ຈະດື່ມ? (ການບຳບັດເພື່ອໃຊ້ໃນຄົວເຮືອນເທົ່ານັ້ນ)		
Coding categories		Coding categories	
ບໍ່ມີການປຸງແຕ່ງເລີຍ /ດື່ມເລີຍ	11	ຂ້າເຊື້ອດ້ວຍ ກລໍ	21
ປະໃຫ້ມີການຕົກຕະກອນ	13	ເຮັດໃຫ້ຕົກຕະກອນດ້ວຍສານສົ້ມຫຼືສານເຄມີອື່ນໆ	23
ຕົ້ມ	15	ຂ້າເຊື້ອດ້ວຍ ແສງຕາເວັນ	25
ກອງດ້ວຍຜ້າ	17		
ກອງລະອຽດ (ດ້ວຍ Ceramic, ຊາຍ)	19	ອື່ນໆ =Other	Code 96
		(ໃຫ້ລະບຸ) =Specify	

Figure 6.5: Question in the Lao survey containing an "other" category.

Coder bias is usually a result of poor training or incomplete instructions, variance in coder performance (i.e., tiredness, illness), data entry errors, or machine malfunction (some processing errors are caused by errors in the computer programs) (StatCan 1999).

Data capturing

During data capture information is transferred from coded papers to an electronic format more suitable for data analysis. The design of the *WaSH* survey questionnaire only requires numeric data entry. To reduce the risk of mistyping data on the computer's numeric keypad, adjoining keys are not used for the last digit of the answer codes (Figure 6.4 and Figure 6.6). To avoid answers being associated with the wrong question in the database, questions use different coding for their answer from the proceeding ones, as shown in Figure 6.6 for the question in Figure 6.4. Suitable software for data capturing can than be programmed to accept only valid answers. This reduces capturing errors by reducing the risk that questions and answers are mixed up in the database.

Figure 6.6: Data entry by numeric keypad

Another possibility to reduce coding errors is to use a barcode reader, for example as a keyboard wedge, to simulate keystrokes from the keyboard.

Question C02A

Is the toilet your household uses:

QC02A01 ❑ **Private** used only by your family;

QC02A02 ❑ **Shared** used by more families but they are known to you;

QC02A03 ❑ **Public** available for use by anybody.

Figure 6.7 : Example of a bar-coded questionnaire

This allows more information to be entered in the coded information, such as the question to which the answer refers, together with the answer (see Figure 6.7) without slowing down data capture.

Capture bias is possible when errors are identified incorrectly during the editing phase. Even when errors are discovered, they can be corrected improperly because of poor imputation procedures.

Consistency check and data cleaning

No matter how carefully data are entered from paper into a computer, chances of an error-free transfer are slim. There are various ways to ensure that the information in digital form is accurate, complete and consistent. The *WaSH* survey opts, like many small surveys, for double data entry. This consists in capturing data independently twice and comparing the two entries using software such as Data Compare[1], EpiData-Entry[2] and CS-Pro[3] (see also section 6.5 on page 223) to spot differences between the captured data. However if an error appears in both files it will go unnoticed.

Consistency checks look for unlikely combinations of answers and triangulate information to check against the paper version where required. While consistency checks can be done manually it is recommended to do these using rules which ca be written in most statistical programmes which allow scripting (StatCan 1999).

Combining variables

Indicators for the *WaSH* are built from multiple variables as shown in Chapter 4. This requires that various pieces of coded and captured data are combined to one binomial value (Figure 4.8 and Figure 4.11). There are two different ways of obtaining indicator values from the collected data.

The first is to calculate automatically the value for each record during data capturing. This means that value for the indicator for each record is known after the data for that record are entered. However if data are corrected in the data set, the indicator values will not automatically be recalculated.

The second method calculates all the indicators for the whole data set once all the records have been entered. This is referred to as post processing. If changes are made to the data set, rerunning the post process gives the new indicator values. Epi-info, the programme chosen for the *WaSH* trial, did not allow for the latter approach, so the former method was selected.

6.4.2 Data analysis

Several different analyses are possible, but the focus in the *WaSH* survey is to obtain three proportions of:

- people not having access to an 'improved' water source;
- people not having access to 'improved' sanitation;
- people not practising 'improved' hygiene behaviour.

[1] Data Compare (CDCs Epi Info 2002 suite) is a programme to compare EpiInfo 2002 data files.

[2] EpiData (Danish EpiData association) has two different ways for comparing double entered data.

[3] CSpro (OCR-Macro) has a "compare data" function allowing to compare two CSpro data files.

Initially the main concern was to enable design-based analyses in order to obtain accurate confidence intervals. This means that the analysis takes into account the cluster sampling plan as discussed in Chapter 5. It is later argued in Chapter 9 that this pedantic approach might not be the most useful focus. Initially stratification was not an option in the methodology as mentioned in Chapter 4, but this had to be reviewed as explained in Chapter 8 and 9.

6.4.3 Documentation and dissemination

While survey results are generally disseminated, data sets are often stored and forgotten. When re-discovered, they are often not very useful because few people can remember what the different variables and codes mean. When data are collected, it has usually more use than just for the purpose it is collected. For that reason, it is good practice to properly document survey data in such a way that people are confident in using the collected data. A good example are the DHS data www.measuredhs.com which are made widely available. The minimum information required include how the data was collected, the indicators and the codes used, as well as details on the sample plan. Some questions must be answered before widely disseminating the data. Who is the owner of the data, and is the privacy of the interviewees respected? The latter might not only require removal of personal details but also deleting some decimals from the GPS coordinates and keeping those in a separate data set which is securely stored.

6.5 Software

Computers are central to data processing in modern surveys. The choice of software recommended for data capture, storage, editing, comparing, analysis and dissemination is an important aspect in making the process more convenient, and hence, the methodology more acceptable. In addition, more complex analyses are possible that previously would have been cumbersome to do by hand or using a calculator. Software is central in the different steps of data processing as shown in Figure 6.3. This section looks at various software tools suitable for the *WaSH* survey methodology in order to evaluate which one would be used in the field trials. Writing a specific piece of software for the *WaSH* survey methodology has more disadvantages than advantages. Developing software is expensive and requires continuous support and development. Purpose build software rarely allows other functions than the purpose they have been written for and makes the methodology dependent on such tools. It would be more logic to assess suitable existing software or support existing software to adapt those for the *WaSH* survey method. Below is a discussion on the various aspects considered important in the choice of such existing software.

6.5.1 Availability

First of all the software has to be *freely available*. Initially the criterion used was that it should be freely available or at a small fee. However, payment, often with credit cards over the internet, was considered a serious obstacle to the availability of such software in low income areas. Setting a cut-off point to determine what consisted 'small fee' was a problem and enough free software was available to restrict the search to free products only. The software had to be suitable for *IBM compatible Personal Computer* (PC) which is the dominant microcomputer system in the world (Hagedoorn 2001). To guarantee future availability and development, the software needs to be directly *supported by an institution or a group of people* rather than developed and owned by an individual. An extensive search on the internet resulted in the downloading of 14 freely available software packages that could be immediately *downloaded from the internet*[1]. Only six of these programmes, listed in Table 6.1, have institutional support guaranteeing their continuity.

Name and (version[2])	Universal Resource Locator (URL)	Support
CS-Pro (ver.2.4)	www.census.gov/ipc/www/cspro	U.S. Census Bureau
EPI-info (ver.6.3) for DOS	www.cdc.gov/epiinfo/Epi6/ei6.htm	CDC Atlanta
EPI-info (ver.3.3) for Windows	www.cdc.gov/epiinfo/index.htm	CDC Atlanta
EPI-Data (ver.3.01)	www.epidata.dk	EPI-Data association
IMPS (ver.4.1.)	www.census.gov/ipc/www/imps/index.html	U.S. Census bureau
Win-IDAMS (ver.1.2)	www.unesco.org/idams	UNESCO

Table 6.1: Free survey software with URL and Supporting organisation

Of these, CS-Pro in Table 6.1 is a successor to an earlier programme called IMPS. The U.S. Census Bureau has ceased supporting IMPS and focuses on developing CS-

[1] Win-IDAMS required a personal user key to activate the software, which is supplied within one working day by UNESCO on simple E-mail request.

[2] Version of the software as downloaded in 2004.

Pro. The DOS version of EPI-info (Table 6.1) has been superseded by the Windows version of EPI-info although it is still widely used. CDC reluctantly supports the DOS version because of its wide use but for further development concentrates only on its Windows version. For these reason IMPS and the DOS version of EPI-info will not be considered further in this section.

6.5.2 Operating system

An operating system or 'platform' is the basic software that enables the computer to run any other software such as the survey software discussed in this section.
IBM™ and IBM-compatible PC systems can run different operating systems (OS). Microsoft Windows™ is the most widely used OS worldwide for desktop computers followed far behind by Linux, Apple™, and others. Microsoft, however, is proprietary software unlike the free open source alternative, Linux. This is one of the many reasons why the latter is seen as a suitable alternative in low-income countries (Rais 2005; Stallman 2003; Wheeler 2005).
Unfortunately all software packages mentioned in Table 6.1 concentrated on MS-Windows as their operating system of choice. Only EPI-data association is considering a version of EPI-Data for LINUX but for the moment this is not seen as a priority (Lauritsen 2004).

6.5.3 Installation

Ease of installation is one of the criteria that make software user-friendly. All packages installed without a problem with exception of the Windows version of EPI-info. EPI-info needed to update various files of the Windows operating system. According to the developers at CDC these problems have since been solved. EPI-Data needed the least space (Table 6.2) and least powerful computer to properly install and run. It is the only program that prides itself in not intervening with the computer's set-up. This is an obvious advantage, because it it could be run from a removable disk or memory stick if not enough space is available on the computer's hard disk. This is very convenient when older computers are used, which is common during field surveys in low-income countries.

Name and (version[1])	Space required (mb)
CS-Pro (ver.2.4)	15 mb
EPI-info (ver.3.3) for Windows	57 mb
EPI-Data (ver.3.01)	4 mb
Win-IDAMS (ver.1.2)	11 mb

Table 6.2: Space required in megabytes for installing each programme

Apart from Epi-Data which runs happily on older processors, all software required minimum Pentium II processors or higher. Epi-info was the slowest programme of all four, requiring at least a Pentium III.

Below in Table 6.3 are the features available in each of the software packages. Ease of *installation* in Table 6.3 was assessed by installation of these programmes on five different computers, *ease of use* was determined from the number of pages that had to be read and the time that was required to put a small test questionnaire in the programme.

Software version[1]	Ease of installation	Ease of use	Technical support	Data entry facilities	Codebook	Consistency check	Double data entry	Data 'cleaning'	Data post processing	Support scripts	Data analysis	Cluster data analysis
CS-Pro (ver.2.4)	+	-	-	++	++	+	+	+	+	+	-①	-
EPI-info (WinV3.3)	+	+	+	++	-	+	+	-	-②	+	++	++
EPI-Data (ver.3.01)	++	++	+	++	++	++	+	+	+	+	-①	-
Win-IDAMS (ver.1.2)	+	+	-	-	-	-	-		-	+	++	++

① Can make frequency tables; ② Does not allow analysis of data combined in post processing
++ very good; + good/available, - bad/non-available

Table 6.3: Features as available in data processing software packages

Technical support was assessed by a genuine question by e-mail, on information unavailable in the documentation or on the Web. For Epi-info this e-mail related to a question on an error in the programme.

[1] Version of the software as downloaded in 2004

Data entry facilities were judged on the convenience of entering data and the convenient functions such as pop-up messages when errors are made during data entry. *Code book* is additional information linked to the data file documenting each variable. Code books generally require a more structural approach to designing data bases for data entry. *Consistency check* allows a script to run before and after each entry as required, in order to limit entries to valid codes, calculate results, combine variables or send pop-up messages.

Double data entry was judged on the availability of this function. For example, EPI-Data has two different ways of verifying data. One compares both files, while the other option checks the file immediately when data are entered for the second time. This allows for immediate remediation during the double entry.

Data cleaning was evaluated by how easy it was to identify a possible error and to correct it in the data set. In EPI-info, for example, the two functions are done in separate programmes which cannot access the dataset simultaneously.

Post processing is convenient to evaluate other combinations of data or create other indicators. During the assessment, for example, EPI-info could create these variables but the protocol used (SQL-script) did not allow for analysis or saving of the created data. Although it was not considered important before the field trial, it proved to be very important during the field trials as will be discussed in Chapter 9.

Data analysis regarded the possibility of doing simple analysis, while *cluster data analysis*, referred to the possibility to account for clustering in the data analysis.

The most complete and structured data entry is CS-Pro but it requires so much training that it is unsuitable for occasional surveys. Epi-Data on the contrary was the easiest programme for data entry but like CS-Pro it only allows for making frequency tables as analyses. While EPI-info is not as convenient as Epi-Data and as complex as CS-Pro, it allows for complex analysis. Not to overburden survey staff in having to learn multiple programmes, the windows version of EPI-info was preferred over all the other available software. This choice was made despite that EPI-info requires powerful computers, which although available for the field trials will not be available to all stakeholders of the *WaSH* methodology.

6.6 Required survey staff training

For a normal *WaSH* survey (without the validation discussed in Chapter 4) it is estimated that 15 people would be able to do the field survey in one month (Annex F). During this period, one week is required for the final on-the-ground preparation and field staff training, two weeks for data collection and one week to finalise data entry and presentation of intermediate results.

For the validation work (Annex F) an extra 10 people are required to carry out the structural observations.

The complete list is as follows:

Function	Quantity
Local survey supervisor	1
Assistant supervisors	2
Data Entry	2
Interviewers (*WaSH* survey)	12
Observers[1] (Validation during field trials)	10
Drivers	2
Total	29

Table 6.4: Staff requirements for field trials of WaSH survey

To reduce the size of the groups being taught, two different trainings programmes were foreseen.

Two training days are used for all the staff but the observers, and two training days for the observers alone. To give an idea about the topics covered in the training, an example of the training programme used in the Kenyan trial is attached in Annex G and the topics covered are listed below.

- Introduction to each other (games)
- Introduction to the organisation doing the survey
- Goal of the study
- Role of the various staff in the survey

[1] This function will not be required in the final *WaSH* survey method.

- Introduction to the questionnaire (interviewers only)
- How to fill in the questionnaire
- Introduction to the structured observation forms (observers only)
- Translation of questionnaires into Swahili and other languages (and back translation to English) (interviewers only)
- Back translation of questionnaire to English as a check (observers)
- Selecting the ideal respondent
- Methods of asking a question (interviewers only)
- Introduction, body language, climate setting, ending the interview
- Dealing with non-response and refusal to participate
- Dealing with aggression and insecurity
- Field sampling
- Introduction to data coding in EPI-info
- Detailed use of EPI-info (Data entry staff and supervising staff)
- Piloting and reviewing survey tools
- Practical information

In the *WaSH* survey the plan is to make the interviewers' training of the part of the final preparations for the survey and to explain clearly the goals and difficulties in data collection. This would include forward and backward translation of all questionnaires, in all the languages known by the interviewers and relevant to the study area.

6.7 Summary

This chapter shows that practical data collection has a significant impact on the accuracy of data collection. The extent of this impact probably outweighs the errors due to the chosen method of sampling and the sample size. Despite this, sampling errors are far better covered in literature than non-sampling errors. The *WaSH* survey methodology aims the possibility to commission surveys using people who are not specialists in surveying. This will require paying attention to proper training and motivation in order to reduce non-sampling errors. However there are hardly any guidelines available to establish the most important issues in this regard.

CHAPTER 7 NARRATIVE OF FIELD-TESTING THE SURVEY METHODOLOGY

7.1 Introduction

Chapters 2 to 6 focused on the theoretical basis and development of the *WaSH* survey methodology. This chapter is a narrative of four field tests of the survey methodology in which the author was to various degrees involved. The need for field-testing of a sector specific survey method was expressed in a meeting on the 18 June 2002 at the WSSCC headquarters in Geneva. At the time it was agreed that trials should take place in at least six countries. Such trials would, according to the meeting, have to include 'at least one urban setting, have at least one each in Africa, Asia and Latin America' and should include rural, urban and peri-urban situations. The following day a strategic planning meeting was held in which various field trial sites were selected and linked to potential funding. The goal was to plan as many trials as possible before the World Water Forum held in Kyoto, Japan in March 2003.

The three main selection criteria for a field trial location agreed at the meeting were:

- strong counterpart collaborators with experience of social research;
- collaborative authorities in view of the limited time for implementation;
- potential funding available for the survey through an identified funding agency.

The aim of the field trials was to yield two kinds of data:

- lessons relating to the methodology itself to promote further development;
- providing coverage figures for water supply, sanitation and hygiene for the survey area.

However none of the trials planned at the meeting materialised. WSSCC[1] was able to fund a trial with one of their 'Southern' partners. As the Kyoto summit was only some months away Nairobi was chosen as a location and NETWAS as an implementation partner. Not only were the conditions deemed suitable for a trial but

[1] WSSCC had stated in the June 2002 meeting that although they would be happy to partially contribute to a trial involving WSSCC partners, they were unable at the time to fully fund such a trial.

it was hoped in vain that the author's familiarity with Kenya and NETWAS could speed up the survey implementation.

Before the decision for the field Kenyan field trial two requests to use the draft protocol were received:

- The first from an MSc student working for WHO, who wanted to evaluate her former project in Kosovo;
- South Africa requested support to test the indicators in Kwazulu-Natal in relation to a re-occurring cholera epidemic which was attributed to poor sanitation provision in the area.

At that time only the initial draft documents on the *WaSH* indicators were written.

After the Kyoto Water Forum the World Bank was also willing to fund one survey to test the methodology and agreed on a trial in Asia. This became the Laos survey which is the fourth survey covered in this chapter (Table 7.1).

		Organisation	
Date	Location	Implementing	Funding
July - Aug. 2002	Malisheve, Kosovo	Institute of Public Health, MSc student LSHTM	UNMIK
Nov.- Dec. 2002	Kwazulu Natal, South Africa	Ikhwelonet Consortium & Research and Management	Umgeni Water
Jan. - Feb. 2003	Nairobi , Kenya	NETWAS, LSHTM*	WSSCC
Aug.- Sept. 2003	Khakhek, Laos	URI, LSHTM*	World Bank

* Surveys in which the author was fully involved.

Table 7.1: Field trials covered in this chapter

7.2 Trial in Kosovo

7.2.1 Introduction

The first survey based on the draft *WaSH* indicator documents was held in Kosovo (McWeeney 2002). The survey was designed, planned and implemented in 2002 by

Geraldine McWeeney as an MSc project in 'Environmental Epidemiology and Policy' at the London School of Hygiene and Tropical Medicine (LSHTM). It was implemented by the Kosovo Institute of Public Health (IPH) and supported by the World Health Organisation (WHO) office in Kosovo and funded by the United Nations Mission in Kosovo (UNMIK). She used the initial draft documents describing the *WaSH* survey methodology and some initial support from the author to design a sampling strategy.

The survey itself was held in Malisheve municipality with piloting of the methodology and training of the surveyors done in Besi village which is part of Pristina. Field testing was done in Terpeze Village of Malisheve municipality while the full survey was done in Malisheve town.

Information in this section is based on McWeeney's MSc report (2002) and a debrief on her return. The author's involvement was limited to providing the drafts documents on the *WaSH* indicators and answering sporadic questions.

7.2.2 Aims and objectives of the study

The overall objectives are to *"...establish appropriateness of draft indicators for access and use of water, sanitation and hygiene practices through:*

1. *A trial of indicators for access and use of:*
    a. *drinking water*
    b. *non-drinking water*
    c. *sanitation*
    d. *wastewater disposal*
    e. *hygiene activities*
2. *Review and adjustment of indicators in response to pilot studies and survey outcomes.*
3. *Development of a preliminary training programme for surveyors with non-technical background."*

7.2.3 Study area

Figure 7.1: Location of the study area in Kosovo

Malisheve municipality is located in the centre of Kosovo, south west of the Capital Pristina. Although Malisheve town is the administrative capital of Malisheve municipality it has characteristics more in line with rural areas of Kosovo. International 'interest' in the area is due to past armed conflict and current tension between ethnic Albanian and Serbs living in the area.

7.2.4 Survey questionnaire

The questionnaire used was the first draft as submitted to the WSSCC Monitoring Task Force but modified based on results from piloting the questionnaire in Kosovo. Some of the changes made were:

For question "*Where do you usually wash your hands?*" more possible answers were added as the location where people washed their hands depended on the season (for example, locations inside and outside the dwelling), which made answering the question difficult.

The question "*When do you usually wash your hands*" required some additional answer categories but it was found to be an unsuitable question to ask because it expressed more knowledge than practice. People who frequently wash their hand might do this unconsciously which results in an answer that does not reflect their practice.

The schoolchildren part was omitted because no schoolchildren could be found for questioning at the household.

The question "*What kind of toilet facilities does your household use*" was given more subcategories, in particular for flush latrines, to specify where effluent was flushed to. The observation "*Is the drop hole free from visible excreta?*" was extend to include the shoot common in rural Kosovo toilet design. Regarding seasonality the question was rephrased to which months the source in question was NOT available. Some questions on wastewater disposal were added on the request of IPH.

7.2.5 Sampling

Definition of population of interest

Identification of the populations of interest was done in collaboration with IPH following communications from the UK.

Selection was based on the following criteria:

a. information on community water, sanitation and hygiene should already be available from previous surveys or from information held by IHP
b. accessibility from the capital Pristina
c. clearly defined population
d. co-operative municipal administration and structure
e. communities (clusters) with more than 100 households

Terpeze and Malisheve town in Malisheve Municipaly were the two places selected. Apart from information on hygiene behaviour which is not available for any location in Kosovo, they both appeared to fulfil the above criteria. Updated information on water and sanitation in Malisheve town was available through a recent water and sewerage network survey of the town (Parsons Delaware Inc. 2002).

Population data were collected on the two selected locations through the municipal authorities: IPH, UNHCR, USAID and the Kosovo Cadastral Institute in Pristina.

Preparations for a cluster survey were made from London, based on initial figures of around 3000 households. This would result in small clusters because the required sample size initially calculated was 1024 households, based on 32 clusters of 32 samples. On arrival in Kosovo the researcher realised that most people had left the town due to insecurity, which had resulted in an over-estimation of the number of households. No accurate figures were available but in discussion with the municipal administration, the Mothers' Society, Kosovar Statistical Office and IHP, the approximate figure was estimated between 120 to 300 households. A figure of around 300 buildings was further confirmed by aerial photographs. These low population figures made cluster sampling impossible and SRS more appropriate. While preparing listings to make a simple random sample of 96 households (see Equation 7.1) it became clear that a large proportion of existing houses from existing household listings were also inhabited.

$$n \geq \frac{z^2 P_x(1-P_x)}{d^2}$$

$$n \geq \frac{1.96^2 \times 50(1-50)}{10^2}$$

$$n \geq 96.04 \cong 96$$

n Sample size

z Reliability coefficient (<u>1.96</u> for a 95% reliability)
d Absolute deviation (% points) of the result (<u>10% points</u>)
P_x Unknown population proportion for outcome (<u>50%</u>).

(Levy 1999)

Equation 7.1: Sample size calculation for SRS in Malisheve town

Due to time constraints and the continuing uncertainty about the number of households, a decision was taken to do a census of the town rather than take a sample. This resulted in a survey of 101 households. A household was defined by the survey team as people that spent the last night under the same roof.

Non-responding households were few and were revisited at a later time or date. Most of the people lived together with their extended family, seeking security in numbers as well lacking the funds to find individual housing. The fear of robbery almost guaranteed at least one person of the household present in the house at any time. If the house was unattended it is usually for very short periods which resulted in a 100% success rate when revisiting the non-responding households.

7.2.6 Practical implementation

Consent to collect data

Consent to collect data was obtained from the provisional administration by the United Nations in Kosovo (UNMIK), the local Malisheve Municipal Administration and community leaders from the villages to be surveyed. Detailed information on the purpose of the survey, questionnaire and activities were discussed with the above authorities and the IPH water and sanitation unit, UNMIK Public Utilities Department, European Agency for reconstruction (EAR) Water and Environment Department, World Health Organisation (WHO) in Kosovo and the United States Agency for International Development (USAID).

Fieldworkers training and validation

Although the *"development of a preliminary training programme for surveyors with non-technical background"* was one of the aims of the survey, it was not achieved. As the cluster surveying was not possible, only a reduced team of two surveyors was used. The surveyors were IPH staff made available for the survey. The training involved:

- explanations of the methodology;
- double translations of questionnaires English→ Albanian→ English
- role play
- piloting and involvement in the adaptation of the survey questionnaire.

Questionnaire and indicators

Hardly any *"other"* were filled into the questionnaire as response category. This could indicate that response category options are adequate. Although considered unlikely by the survey coordinator, it could also mean the option was not understood or surveyors felt pressured in avoiding this option. In the town of Malisheve as well as in the testing phases there were some problems coding answers. When for example, tanker trucks filled up household dug-wells the tanker truck, considered not an appropriate water source, became an appropriate source when the dug-well was protected (Table 4.5).

Data imputation and coding

The field work for the survey took five days which was less than the planned two weeks for the cluster survey. This was due to the reduced sample, from the planned 1024 samples to 101 households. There was no time lost in looking for particular households as the survey became a census with very few revisits required due to non-response. Each lunchtime, data was entered into a spreadsheet and checked through double data entry. This allowed for the verification of inconsistency or possible errors the same afternoon or the next day, although double entry consistency check was performed is unclear from the thesis who carried this out (McWeeney 2002).
Data analysis was undertaken in the same spreadsheet using the statistical functions of the Excel software. This option was preferred as the local staff where familiar with these tools while there were problems encountered running the statistical program Stata 7.

Data collection precision and bias

Although the initial idea was to compare the results with previous data collected, differences in definitions and the regular omission of any clear definition on which existing and historical access figures are based made this impossible. Moreover most data did not clearly state the population covered by the survey.

Cost and repeatability

In Kosovo, the cost of the survey was considered sustainable and IHP felt strongly they could repeat such a survey on their own. They mentioned that the whole task was performed at low cost and it produced rapid and clear findings.

7.2.7 Conclusions from the Kosovo survey

Based on McWeeney's report (2002) it seems women are more aware of hygiene practices than men which might make the generalisation of this indicator at the household level a problem. In Kosovo the women mainly take care of young children which includes changing diapers. When men were interviewed, it was felt that another pattern might emerge if a woman in the same household had been interviewed. Socio-economic status seems to be a confounder for the relationship between access and behaviour. The surveyors were initially reluctant to do some of the observation required in the survey, as they felt that this was an invasion of privacy. This seemed to be based on the assumption that interviewees would also be reluctant to show their toilets, but this did not appear to be the case in the majority of households.

The conclusion was that the methodology had strengths and weaknesses. It was welcomed on the basis that it was long overdue. The weaknesses, such as an imperfect indicator and difficulty in combining data for analysis, were not considered very important at this stage as no validation of the alternative data collecting methods could be found in literature. The implementation organisation IPH, as well as the MSc student, admitted openly their discomfort with the sampling and analysis in the survey. These two points will require more attention in the description of the *WaSH* survey methodology in future.

7.2.8 Policy relevance

In Kosovo considerable interest was shown in this study by the various stakeholders for health and utilities in Kosovo such as IPH, Department for the Environment, Public Utilities Department and the local municipal structures. The IPH expressed interest in adding the tried, tested and accepted survey to their sanitary inspector's questionnaire thereby producing constantly updated information for the global database. It was considered a useful tool for policy development in the local, national and international context and international organisations demonstrated interest in the methodology.

7.3 South-African Trial

7.3.1 Introduction

The second survey based on the first draft of *WaSH* indicators was a South-African trial in Kwazulu-Natal. The survey was designed, planned and implemented by 'Ikhwelonet Consortium' and 'Research & Management' in mid-December 2002 and supported financially by the South African Department of Water Affairs and Forestry. This section on the South African trial contains information based on:

- feedback on the survey methodology as documented in the survey report;
- a presentation given by Umgeni Water at the World Water Forum held in Kyoto, Japan in March 2003;
- a brief discussion with two people involved in coordinating the survey:
    - Minnie Venter-Hildebrand of Umgeni Water and author of the survey report (Venter-Hildebrand 2003)
    - Jayant N. Bhagwan, Director of Water Use and Waste Management at the South African Water Research Commission

Despite the author's efforts to become more involved in this survey, his support was no further than supplying the draft documentation and replying to sporadic queries.

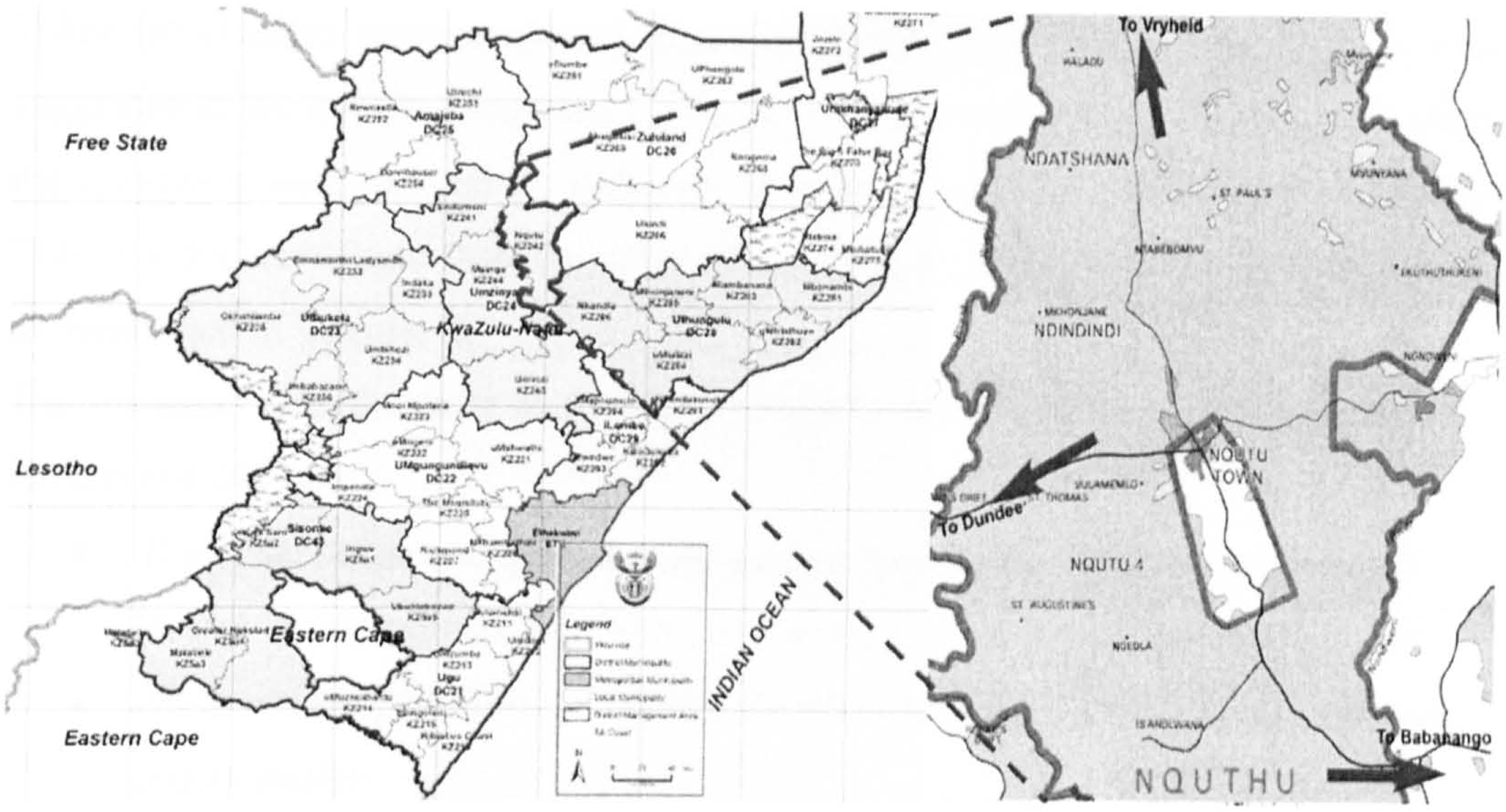
7.3.2 Aims and objectives

The aims of the survey were (Venter-Hildebrand 2003):

- test and pilot the WSSCC *WaSH* indicator toolkit[2] and questionnaire in Kwazulu Natal;
- apply the questions to the project;
- capture the data generated;
- synthesize the data;
- link the outputs of this exercise with the international WSSCC initiative;
- produce and present the results.

[2] The documents on the *WaSH* survey methodology contained at the time only information on indicators referred to by the South African research team as an 'indicator toolkit'

7.3.3 Study area



The South-African trial was held in seven remote villages (Ndatshana, Ndindindi, Ngoboti[3], Ngobintsimbi[3], Jabavu[1], Ngonini[1], Masotsheni[1]) in Northern Kwazulu-Natal. This area was chosen because it was identified by the South African Water Research Commission and the Department of Water Affaires and Forestry (South Africa) as a cholera area (Venter-Hildebrand 2003). One of the suspected factors contributing to the yearly epidemical spread of cholera is the lack of proper excreta disposal facilities in this region (Chabalala 2005), hence their interest in a method which measures access to water and sanitation in a simple survey.

7.3.4 Survey questionnaire

The survey in Kwazulu-Natal was based on the same draft document as the Kosovo survey. The implementation organisations were asked by Umgeni Water to add questions relating to training methodologies and training tools used in health and hygiene education. They wanted to include information on the frequency and number of participants (adults and children) involved in such training and the perception of the population towards these activities to allow additional data analysis.

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[3] Actually a community from a village called 'Nqutu-4 which has eight communities'. Although like a sub-village it is throughout the survey report referred to as a village (Venter-Hildebrand 2003)

Questionnaire and indicators

While no changes were suggested to the questions themselves, some changes were suggested to the question sequence. This is no surprise because in the draft document the questions were ordered by indicator to argue a case for a measurable indicator. This is a different logic than the order of question required for household interviews as mentioned in Chapter 4.

The 'original' questionnaire as found in Annex C was reshuffled as follows (Venter-Hildebrand 2003):

- The observation was placed at the end of the questionnaire as observations tended to *"disrupt the interview flow when placed inside the questionnaire"*;
- All questions pertaining to the household were placed at the beginning of the questionnaire;
- All questions pertaining to children were placed in one questionnaire and removed from the household questionnaire. This was done because the team found that, "... (primary school) *children were not present during the interviews with their mothers* ... as they were *...out playing or doing chores"*.

This was partly the way the order was suggested in the initial document. However that document went further than the suggestions in the South African survey report by suggesting that the general questions (less embarrassing ones) were asked first while those that dealt with private issues or could be perceived as embarrassing, were handled towards the end of the survey (see Chapter 4).

As with the Kosovo survey, the children's questionnaire was omitted from the household survey. Although schools were already closed for Christmas holidays it was rare to find children at home as they were playing outside or doing chores.

One problem reported with the question A3 (Annex C) was that households had alternative ways of dealing with children faeces which were not represented in the response categories (Venter-Hildebrand 2003), although the report does not illustrate these different methods. There was also the misconception that if one good behaviour was included in the collected data the household would be classified as having good behaviour. This indicates that neither the principle of compound indicators nor the way the indicators should be calculated was made crystal clear to the reporter and therefore, requires better explanation in the *WaSH* methodology.

7.3.5 Sampling

Representative sampling in this trial proved to be a major problem as will be explained below. This was disturbing as the data was collected by well established research organisations.

Definition of population of interest

In the report there was no explicit definition of the target population. The population seems to be "*a remote rural area in Northern Kwazulu Natal province and an identified cholera area*". The survey also infers the results to a national level, and even admitted that in inferring results of the survey to a national level "*...the sample of 243 households...is too small to extract a national pattern*".
The Later statement is really disconcerting because even if the sample size was larger the survey represented only a small area of South Africa and therefore, this makes it impossible to infer results to a national level.

Cluster selection

To take a representative sample some degree of randomisation is needed. In this trial it seems that the villages were partly (if not wholly) selected out of convenience. The survey report mentions that "*seven villages were identified within an accessible geographical area*". It adds that "*a peripheral consideration in the sampling process was the accessibility of the villages in terms of a road leading to the village and traceable contacts*". With '*traceable contact*' the report seems to indicate that only villages that housed a representative for the sanitation contractor were considered. "*An additional consideration in selecting the villages was the number of primary schools in the in the village and surrounding areas*" which were needed for data collection on schoolchildren. This all seem to indicate a judgemental, if not a convenient, cluster sample. Moreover, as shown in Chapter 5, confidence intervals for cluster surveys with less than 30 clusters are unlikely to achieve adequate confidence interval unless all of the clusters have a homogeneous level of coverage.
Another problem was that the villages as PSU did not provide a list of non-overlapping area units because "*most villages of South Africa's rural areas are difficult to define'* in terms of where the boundaries are. In the survey this was demonstrated by "*...the case of two of the sample villages in which the locals were*

really confused as to where exactly the one village started and the other ended" (Venter-Hildebrand 2003).

Take selection

This take selection process is described in this survey as *"random sampling on the ground"*. The planned selection of the sample in each of the villages had been based on the *"division into blocks for service provision...as demarcated by the local authority"*. The process involved taking "... *a number of houses per block*". The plan was to select randomly household from each block on a map until these maps showed little relation to the reality on the ground. The surveyors opted then for *"random sampling on the ground"* although how this randomisation was approximated was not clear from the survey report. Leaving household selecting over to the surveyors' discretion without a clear protocol reduced the likelihood of representative sampling.

There is also the problem of sample weighting. As the sample plan appeared to divert from *EPSeM*, information on the weights of each sample should have been collected, particularly because the document states that *"this grid* (of service provision blocks) *is not consistent and uniform*"

During discussions on these issues with the survey organisers, they argued that the sample was a **'judgment sample'**. It is a sample based on expert judgment by the '*sanitation contractor in the Newcastle-Dundee area(SA)*'. The critical question is the extent to which such a judgment sample can be relied on to arrive at a representative sample, particularly when a contractor, working on one of the measures of interest, is involved in the site selection. From the information given and the discussion held, the sample seems to be more a **convenience sample**, and the extent to which it is representative is impossible to assess.

This was a survey in which, despite the high level of educated and training of the survey team, a basic understanding of representative sampling was lacking. This became very clear when it was explained to the author that the cost of extending such a survey nationally, was based on 10% of the population being included in the sample. The above stresses one of the major problems in data collection. Once a data-set is collected it is difficult to assess if the initial data collection was done in a representative way unless the sampling selection process is well documented. The method of sampling has consequences in the way the data has to be analysed but also in the way inference can be made to the larger population for which the samples supposed to represent.

The first draft document, on which this survey was based, did explain the *WaSH* indicators but did not contain any information on representative sampling. It is clear that support for survey sampling targeting statistically untrained people will be essential.

7.3.6 Practical implementation

Consent to collect data

Initially the survey team contacted the sanitation field worker of the 'implementing agent' to gain access to the villages. Despite the fact that the field workers lived in these villages, it was impossible for the survey team to obtain an authorisation. So firstly, **traditional leadership** was contacted as "*as village protocol determines such*". Afterwards **political counsellors** were contacted as the political authorities. "*Identifying who these authorities were proved most time consuming*", according to the survey team. The project required contact with the traditional leadership which consisted of contacting the Induna (elder in the house of the chief) to obtain permission to speak to the Nkosi or chief (Venter-Hildebrand 2003). The Indunas consider that researchers who contact the political leaders first or without considering the traditional protocol have offended them and they feel sidelined. However given the delays in approval and a firm decision by the Nkosi, there is no wonder that they are sidelined. So the team took cognisance of this cultural demand and gave appropriate gifts to the traditional leaders, and councillors.

The tension between traditional and political authorities was obvious in the sampling area.

Fieldworkers training and validation

The survey team consisted in six researchers of which:

- two collected survey data for the whole sample;
- two did structured observations in a sub-sample for validation;
- one was the desk researcher;
- one was the data analyst /programmer.

Surveyors and observers were selected for their specific skills which included:

- language;
- territorial familiarity;
- research experience;
- data analysis competence.

Field work training took place over a four-day period with "one day structured training" (sic) and 3 days piloting the questionnaire. The aim of the structured training according to the report *"...focused on ensuring consistency in the data collection methodology and minimized potential subjective biases in the observations"*. How this was done is not clear from the report or later discussions.

Data coding and capturing

As the team where not willing to use free available software they used a programmer to design an Access relational database which runs on a server. Data was captured through a programme written in Visual Basic™ (VB™) under Active Server Pages (ASP). This allowed multiple networked servers to be used for the data entry. After data entry the whole database was transformed to one MS-SQL data base and SQL-scripting language used for data cleaning and analysis. To reduce data entry errors the programme written would have allowed a double data entry, however this was not considered. As elegant as this purpose-made solution seems, it requires a high level of computer literacy and costly licenses to various propriety software. Designing a new purpose build software package is not only expensive but requires continuous support (Chapter 6). For the *WaSH* survey to be convenient to most people, existing free software must be integrated in the methodology (Chapter 6).

Data collection precisions and bias

Expectation of what a survey can bring to a community should not be underestimated. People surveyed *"...showed an intense interest in the project, and being enthused by the hope that further development would reach their village"* (Venter-Hildebrand 2003). While negotiating access and participation to the survey the team was *"...cross-questioned on every minute detail of the survey purpose and aim..."* because participants wanted to assess *"...how this exercise would benefit the livelihood in their village"* (Venter-Hildebrand 2003). According to the survey team water and sanitation was *"...very high priority..."* and resulted in questions such as *"when will we also get latrines"* or question relating to *"the exploitation by bulk* *water supplier".* More practical questions included, *"the children broke the water taps and we don't have money to fix it."* (Venter-Hildebrand 2003). The interviewers involved in the survey were know by the people; one worked for the local sanitation contractor and one for the national water authorities. It would be interesting to examine if there was a significant difference in respond between the two supervisors but the dataset was never made available for this or any other analysis.

In the two first weeks the validation team followed the survey team, selecting a sub-sample of the already surveyed household sample. The research team changed this because of cultural barrier experienced by the validation team. The household behaved differently towards the survey team and the validation team. The validation team observed hygiene practices considered unfamiliar from their known daily habits such as children being send out to the shop to buy soap in order to prove to the observer that they use it to wash their hands. After this, surveyor and observer went to the same household with the observer staying on in the household after the interview to continue the observations. The team found that the later approach allowed for more surreptitious observations starting when the interviewer engaged the household members in the survey.

The reports mentioned how convenient it was that the *"Team members were often invited to share a simple meal or a cup of tea which allowed them to observe hygiene behaviour during meal times".* It is however difficult to assess in how far such behaviour towards visitors is representative of the household's normal behaviour.

7.3.7 Conclusions from the Kwazulu-Natal survey

The survey team in Kwazulu-Natal acknowledges that availability of such a tool was *"long overdue*[4]*".* They have, however, reservations on the practicality of implementing the current (draft) methodology. Not all the information was easy to obtain and combining data in the database towards the indicator was found to be cumbersome. It was felt that by having such a rigorous protocol a lot of useful information was lost. *"Looking at the five*[5] *summative outcomes on their own reduces the value of the information if one expects a formative, qualitative set of outcomes. However once the five outcomes are read in their global context, and balanced*

[4] Same phrase used independently of the Kosovo report while no protocol contain such terms.

[5] The survey looked at drinking & non-drinking water, sanitation, hygiene incl. school sanitation

against the Vision 21 targets , it is clear that internationally it is a most applicable tool to measure progress." (Venter-Hildebrand 2003). Some remarks such as "*the research was expensive and very time consuming, considering the relative small sample*" (Venter-Hildebrand 2003) were mainly related to a misunderstanding of the basic principles of sampling.

A compilation of other conclusion relating to this survey can be found in " (Venter-Hildebrand 2003).

7.4 Survey in an informal settlement of Nairobi, Kenya

7.4.1 Introduction

This survey held on February and March 2003 was implemented by '*Network for Water and Sanitation*' (NETWAS) in Kenya and the '*London School of Hygiene and Tropical Medicine*'. The work was financially supported by WSSCC aiming to feedback information on the methodology into the '*Third World Water Forum*' held in Kyoto early the same year. It was the first survey in which the author was personally involved in the implementation and analysis of the survey.

7.4.2 Aims of the survey

The main aim was to **apply the survey methodology** and learn from its implementation. This was the second time the survey was use in an **African context** and the first time a more complete and revised[6] methodology was implemented.

Specific goals were:

- training of NETWAS staff in basic survey skills;
- **validation of the proposed indicators,** particular hygiene behaviour;
- measure the ***deff.*** and ***roh*** in a water and sanitation specific survey;
- determine the cost ratio between clusters and samples;
- identify practical problems in the survey implementation.

[6] Based on the feedback of the WSSCC monitoring task force meeting on 18 June 2002 and the comments received by correspondence on the revised version.

One of WSSCC main aims in supporting the survey was that the experiences could be presented at the '*Third World Water Forum*' held in Kyoto in March 2003. This left little time for obtaining results from the survey.

7.4.3 Site selection

Criteria for site selection were:

- availability of a sample frame or enough reliable data to build a sampling frame for the whole survey area. This includes:
    - identification of individual households as BSUs and
    - identification of over 32 clearly distinct and not overlapping primary sampling units (PSUs) which have at least 320 households each.
- willingness of local authorities to collaborate.

The initial plan was to hold the survey in Mathare but due to civil unrests at the time, alternative sites as described in Annex H were considered. Korogocho was found the most suitable for the main survey while Kware would be used as an alternative site. Soweto (linked to Soweto in South Africa) was chosen for piloting the survey and training of the surveyors. Unfortunately, and contrary to NETWAS' information, none of the survey areas had, at the time of selection, any suitable information to build a reliable sample frame.

7.4.4 Consent to collect data

Authorisations to collect data by the implementing partner were obtained from the Nairobi Provincial Commissioners and the local political authorities. Chief Mutai, the highest political authority in the informal settlement of Korogocho, had, despite being politically appointed, the trust of the community from which he originated. He was instrumental in obtaining the consent of the village elders and traditional authorities.

7.4.5 Selection of survey staff

There were two different profiles selected for the survey. The first group were the **interviewers** for the *WaSH* survey which were selected from the same region but not from Korogocho, the survey area. The aim was to find people with which the interviewees could enjoy some level of informality while making sure no information was exchanged between people known to each other. The requirements for interviewers were fluent in English and Swahili with good writing skills and willing to follow some simple rules in the process of collection data. They had to be acceptable to the authorities as well as to the interviewees. The aim was to have a gender balanced survey team. In discussion with NETWAS it was decided to invite high school students who had no previous experience in survey work and train them to do the survey. The same survey people would than be used for other survey work in the same informal settlement subsequent to the *WaSH* survey.

The second group of survey staff were **observers** who had to validate the data collected in the interviews in a sub sample of the interviewed households. This group required previous experience in structured observation and were selected from NETWAS staff and NETWAS collaborators.

The numbers of required staff was estimated as follows:

The *WaSH* cluster survey requires 32 households in each of the 32 clusters which results in 32 x 32 = 1024 interviews. No extra households were added to compensate for expected non-response due to lack of resources. For the sample size the worst case of 50% prevalence was used as explained in Chapter 5.

The survey was planned to take two weeks which contains 10 working days. The budget contained 14 days for data collection and weekend work was agreed with the survey staff prior to their hiring. It was agreed that this option would only be used if required.

With a total of 1024 interviews required during the survey the daily capacity will be 1024 interviews /10 working days or 102.4 interviews per day. Taking into account that an estimated 15% will have to be revisited because of non-response or missing data the daily interview capacity had to be raised to: 102.4 +15% = 117.76 ≈ <u>118 interviews per day</u>.

It was estimated that finding the household, introduction, data collection and wrapping up should not take longer than 30 minutes/household. This would give each surveyor the possibility to do <u>10 interviews a day</u> and allow 3 hours for briefing debriefing and lunch time in an 8 hour working day.

(118 interviews per day)/(10 interviews per day per interviewer)= results in 11.8 ≈ 12 interviewers. This gives the whole survey a capacity of:

10 days x 10 interviews/day/interviewer x 12 interviewers = <u>1200 interviews</u>.

For the observers who only could survey one household a day the number of observers was minimum 11 and as there was less margin for recapturing the 15% revisiting rate resulted in the selection of **14 observers** when rounding upwards.

7.4.6 Training of survey staff

NETWAS, being a training organisation, was comfortable in training the survey staff. A four-day training programme was drafted, in which the first two days concentrated on the interviewers and the second two days on the observers (planned training programme in Annex G. The training included an explanation of the project's aim and the purpose of the Kenyan survey in particular. During the training the questionnaire was discussed, translated into various local languages and back into English. The trainees were explained how to identify households; deal with elders accompanying the surveyors and general behaviour during an interview. Due to the type of settlement issues on security and how to deal with aggression were important aspects of the survey training. The training included piloting of the questionnaire as well as consequent revision of the questionnaire and the various translations. After explaining what would happen with the collected information the training was closed with practical information for the survey staff.

7.4.7 Data collected

The questionnaire used in Kenya (Annex C) was the second draft which took into account feedback received by correspondence from the WSSCC Monitoring Task and from the organisers of the Kosovo and South African trial. To this were added changes made based on the piloting of questionnaire in Kenya.

The biggest change was the omission of the questions on school sanitation for primary school children in the household as these children proved often to be unavailable during the survey. Instead two questions were added to determine how many children in the household were going to a primary school and how many of those were available at the household during the interview.

7.4.8 Sampling

Basic Sampling Unit and definition of population

The population for the survey was defined by the household living within the Korogocho settlement. The population of interest is clearly physically and administratively defined. The target population was drawn from this informal settlement which contained 'temporary' houses, i.e. constructed from recycled material with an ownership which is ill defined. The settlement is surrounded by housing in solid construction materials of which ownership is clear and official (Figure 7.2).

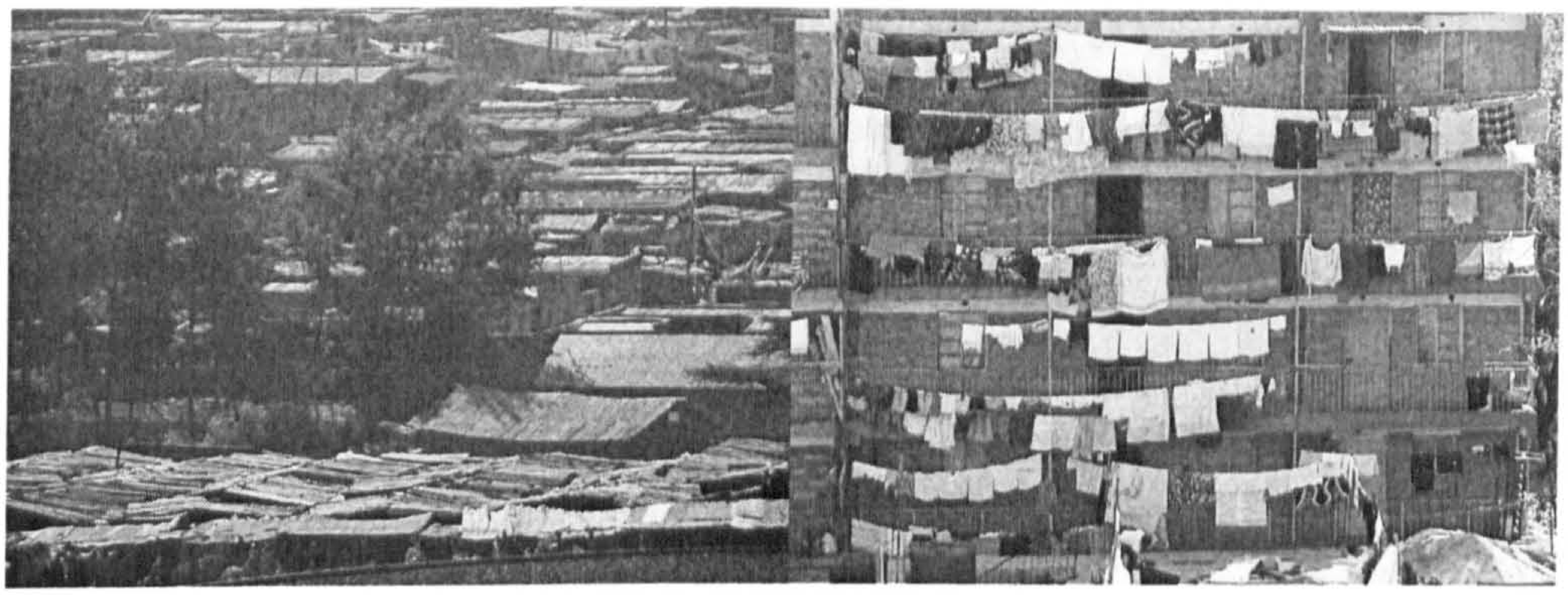


Figure 7.2: Left Korogocho with on the right buildings surrounding the informal settlement.

This is in clear contrast with the target populations in the settlement who live in housing from corrugated steel sheeting and recycled material. The contours of the various villages are physically less clearly delineated but people within the settlement are very clear about which village they belong to.

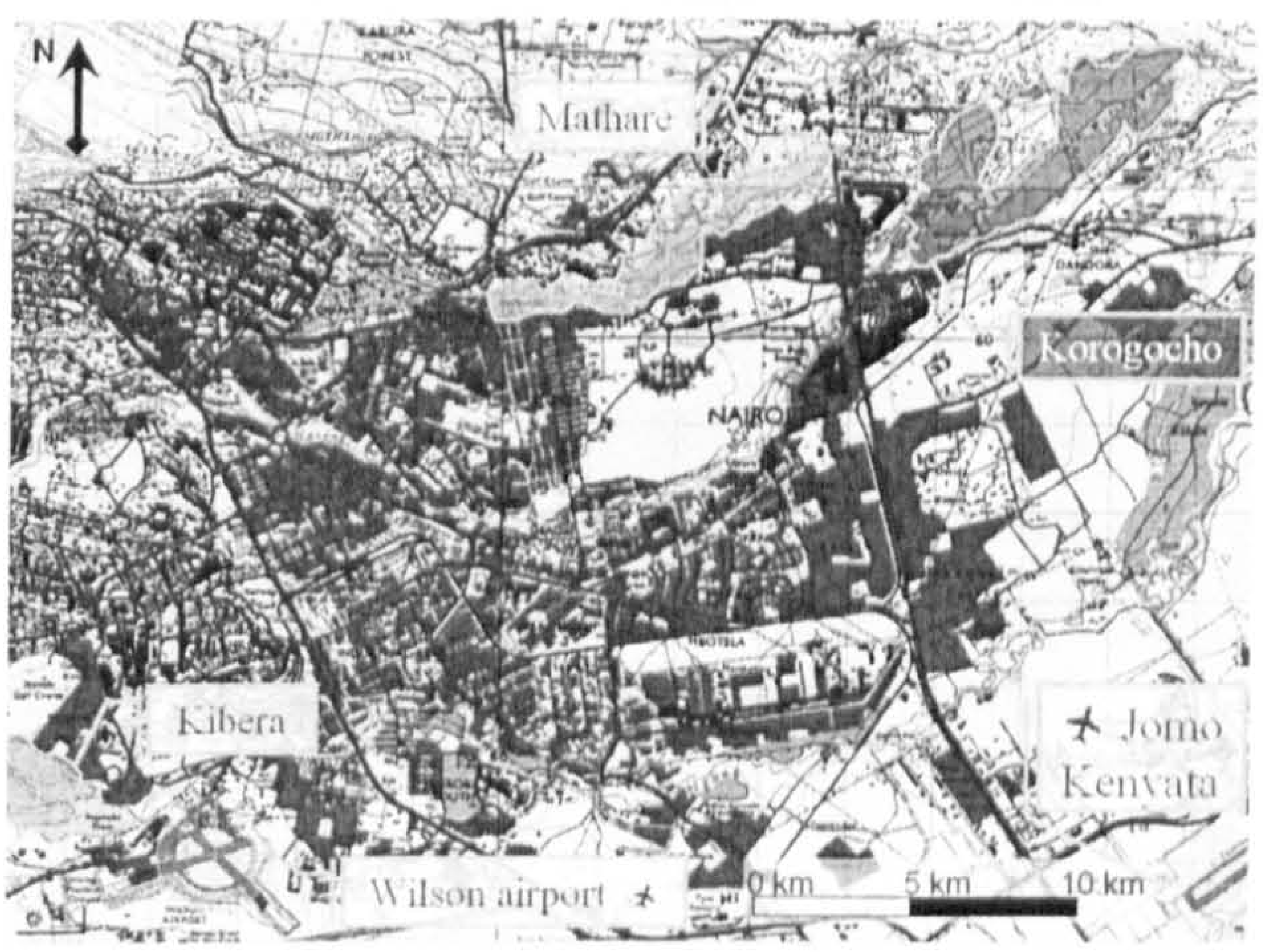


Figure 7.3: Location of Korgocho and Mathare in Nairobi

A sample frame was identified through books that listed all the 'plots' or 'compounds' with their 'owner' and how many 'rooms' each compound contained. The identification number on books could be found back painted on the compound doors of each plot as shown in Figure 7.4

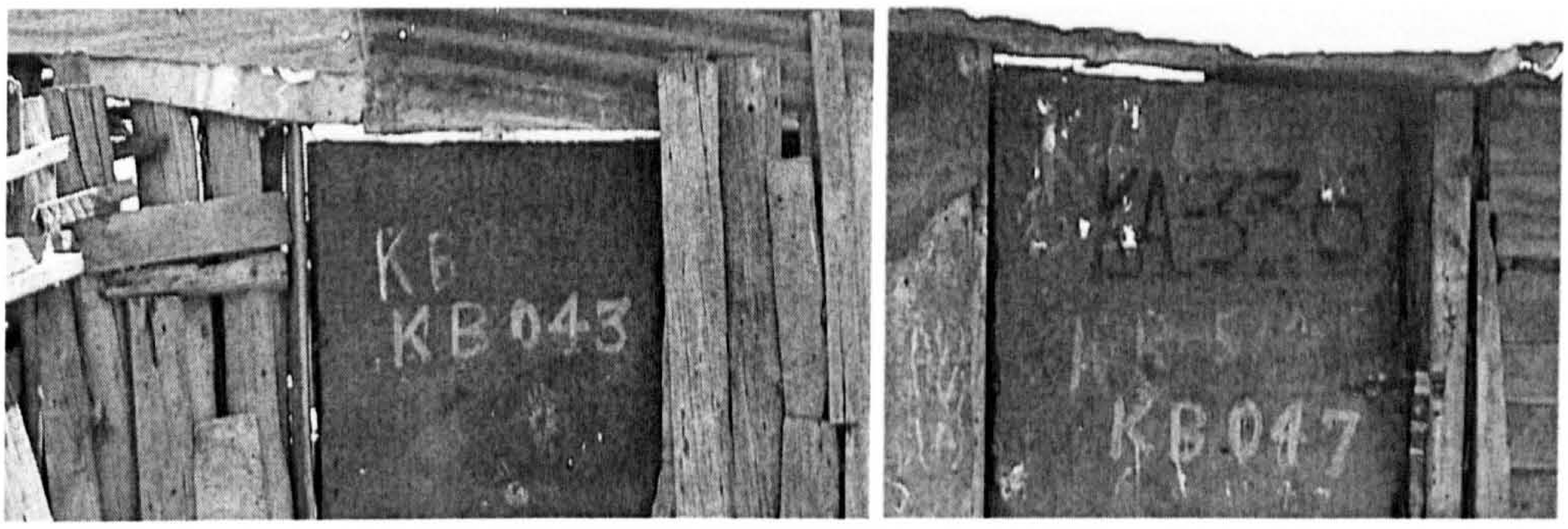


Figure 7.4: ID Numbers on compound doors in Korogocho B

This is claimed 'ownership' because despite many promises the land is still owned by the government. The superstructures are 'owned' by the first people staking a claim on the plot of land by constructing a dwelling on it. Over time these plot are filled with rooms built around a central area, forming a closed compound. Renting out these rooms is a very lucrative business within the settlement. Each of these 'single room constructions' is rented by a household. In exceptional cases some household might rent two or more rooms but it is rare. In the survey sample only one of the sampled households rented two rooms.

Number of (rooms) households / plot	Number of plots in %	Cumulative %
1	15%	15%
2	16%	31%
3	11%	43%
4	19%	62%
5	8%	70%
6	12%	82%
7	3%	85%
8	6%	91%
9	1%	92%
10	4%	96%
>10	4%	100%

Table 7.2: Number of rooms per plot in Korogocho, Kenya

The **basic sampling unit** for the survey are households. In practice this would be a **'room'** in a compound and if multiple rooms were used by the same household the definition for a household found to be the most suitable by the survey staff was "*those whose food is prepared by the same person the night before*".

Korogocho consists of eight villages:

- Kisumu Ndogo
- Korogocho A
- Korogocho B
- Highridge
- Gitathuru
- (Ngunyumy)
- (Grogan A)
- (Grogan B)

(…) excluded from survey population due to a high level of insecurity.

Due to a lack of security three smaller villages, Ngunyumy and Grogan A and B, were excluded from the survey population. Household listing from these villages was not even available due to this insecurity and lawlessness. They are considered small compared to the other selected areas and based on their surface and their relative low housing density, are estimated to represent less than 10% of the whole informal settlement. However in reality little concrete evidence is available on how many people live in those villages. Due to their particular situation regarding insecurity and lawlessness, these three villages are also likely to be significantly different from the rest of Korogocho.

Based on the 1997 census estimates ±150'000 people lived in the whole of Korogocho, Ngunyumy, Grogan A and B included. According to the listings, coded in a database for this survey, there were 4376 (rooms) households on the sample list (excl. Ngunyumy, and Grogan A and B). The listings were estimated to be five years old which date them to around the 1997 census and, although it was difficult to confirm, might have been part of that census.

If the average size of the household is seven people (estimate based on previous NETWAS surveys in the settlement[7]) then it follows that there should be 21,429 households/rooms (150 000/7= 21,429). If that is the case the listings contain only 20% of the whole of Korogocho. However there is no doubt that the survey area, Korogocho excluding Ngunyumy, and Grogan A and B, represents much more that 20% of Korogocho. A a result of such a low coverage of the population in the sample frame Kware was considered as an alternative side for the survey.

Kware had been recently organised into various plots and ownership was, according to the authorities, clear. The plot listing appeared to be more complete and up-to-date (roughly a year old) in comparison with the books obtained in Korogocho. However after the first day of surveying, it was discovered that people in Kware were so hostile and un-cooperative towards the surveyors that ±95% of the 120 interviews were refused and all of the observation planned the day before could not take place. The problem lay with the recent expropriation of plots by the national authorities and the uncertainty felt by many people living on the new delimited plots. While the issue of ownership may have been clear to the authorities, it was far from clear for the people living on the plots and many did not know who was the owner of their plot or if they would have to pay rent in future. This made them very reluctant to give any kind of information as it was feared that this could be used to assess their purchasing power.

Running out of time, there seem to be no other option but to continue in Korogocho.

Lack of coverage with potential coverage errors was not the only problem in Korogocho. Despite having some kind of sample frame for the survey area, there was no possibility of dividing the area up into over 32 PSUs to do a cluster survey. As a result of the lack of such clusters a **simple random sampling** strategy was chosen for the survey. Giving up on the cluster sample design also meant giving up on the measurement of ***deff*** and ***roh*** in such survey design.

Changes to the sampling design

To obtain a single random sample the households the plots were listed in a random order in a spreadsheet. As the plots did not have equal numbers of rooms/families (Table 7.2) a systematic sample, with a probability proportionate to the size of the

[7] The way this figure was obtained proved to be flawed but it was the only figure available at the time. There was no basis for arguing this figure was wrong even though it seemed high.

plot was selected from the listed plots. The order of selection was noted and kept while additional samples were selected on a day to day basis so no geographical areas would be excluded if the survey was not able to interview all the selected households. The surveyors were trained to select randomly a household in the selected plot by giving each room a number and putting these numbers on little papers in a non-transparent bag. The number selected from the bag would be the randomly selected household.

Simple random sample would require only 96 households to be sampled to attain the same confidence intervals as the initial cluster survey design (Equation 5.1. As the whole survey was geared towards interviewing of 1024 households this was kept as a goal because it would result in more information on practical issues involved in such surveys. It was decided that simple random sample without replacement (through a systematic sample of a daily randomised list) would be done daily until the interview capacity of the team had been reached. If in the process of daily sampling the same compound was selected it would only be excluded from the sample if the same household within the compound was also selected. However during the sampling process no compound was selected twice.

7.4.9 Practical implementation

Non response

Some parts of Korogocho, particular Korogocho A and Korogocho B, are over surveyed and it took sometimes a lot of persuading to involve households into another survey. One successful story to convince people to participate was about a man shouting that there was a lion. Every time the villager would come running in a panic to help the old man just to find him laughing. The man kept on doing his joke until one day a real lion came. He shouted for help but by that time nobody believed him anymore. Nobody came to help.

This story, well know by many people, seem to be a trigger for most of the reluctant participants to take part in the survey.

During the first day the non-response was over 50%. After the second day attempts were made to start the survey earlier in the morning to catch interviewees before they left their home. This meant entering the settlement before dawn when security was still precarious and elders totally unavailable. It meant also for a lot of field workers that they had to leave their house when security was also poor in the area in which they lived and when public transport was sporadic. Arranging pick-up by the NETWAS vehicle was unrealistic because many members of staff lived too far spread out around the outskirts of Nairobi. Using taxies proved logistically and financially infeasible as well. Staying later in the settlements posed similar security and logistical problems. Another way of improving response was using the weekends as shown in Table 7.3 with the assumption that more households would be available, providing they did not work at weekends.

Adding samples was possible without compromising the EPSeM sample design as the sample was a SRS. It was however impossible to keep up with the rate of non-response without extending beyond the four extra days foreseen for data collection shown in Table 7.3.

Day	Date (2003)	Planned activity	Actual activity
1	Mo 24 February	Normal survey work and structured observations	as planned
2	Tu 25 February		
3	We 26 February		
4	Th 27 February		
5	Fr 28 February		
6	**Sa 01 March**	Revisit non response households if required	Revisit non response Households Sa and Su
7	**Su 02 March**		
8	Mo 03 March	Normal survey work and structured observations	As planned but adding revisits towards the end of the week
9	Tu 04 March		
10	We 05 March		
11	Th 06 March		
12	Fr 07 March		
13	**Sa 08 March**	Revisit non response households if required	Saturday revisit non response households, Sunday end of field work *
14	**Su 09 March**		

*Saturday resulted in so few responses during revisits and with all non-respondent households visited at least two times it was considered not useful to get the whole survey team out for another Sunday.

Table 7.3: Adapted work plan to increase the response rate during the Kenya survey

Surveyors, were in addition to their daily household quota, given a supplementary list to use when households in the initial list were:

- destroyed / abandoned;
- did not exist or could not be found;
- vacant / people left for long time;
- changed from domestic function to religious or commercial function;
- under construction.

The category "*Did not exist or could not be found*" should have been omitted in the above list as it could not be confirmed to be a sample frame error unlike the other categories in the list, as will be explained in Chapter 8.

Surveyors in the survey area were accompanied by elders at all times. This was initially to improve cooperation by selected households and to help surveyors to negotiate the labyrinth of the informal settlement. They also proved to be invaluable in ensuring the security of the survey staff. As agreed when either the elder or surveyor felt unsafe interviewing certain households they would not proceed. Another surveyor would revisit those households later with the elder's consent. During the field work one surveyor was mugged[8] and another received a hostile welcome at gunpoint; both indicated that security cannot be taken too seriously.
During the interviewing elders were asked to stay outside the compound, so they did not influence the interview. Initially they found this undignified in their position but this became easier to enforce this once they had been present during initial interviews.

7.4.10 Questionnaire forms

In Kenya there were three sets of forms, shown in Annex Iand briefly discussed in this section.
One form indicated the references of the households to visit during the day. In Annex I the form shown is for 'validators'. The other two sets of forms included one set for the surveyors and one set for the 'validators'. Both sets had one identical single sided '*General information sheet*' which collected data on the household. Each of the set

[8] The surveyor had disobeyed security rules by entering the survey zone unaccompanied by an elder when arriving too late for the morning briefing. He hoped his late arrival would go unnoticed as a result.

were pre-numbered by means of an auto numbering stamp. This allowed a single identifier called the '*form reference*' to be given to the set of forms. Numbers for survey forms were reserved from S0001 to S1999 and validation forms could use numbers V2000 to V2999, number 3000 onwards were used to number the household list. It was assumed that in the basis of the household reference and the basic data sheet describing the household the interview and validation could be matched to form a paired dataset. However this proved to be unreliable and after the first few days, interviewers and observers went to identify the household together to make sure that interview and observation took place in the same household.

Data imputation and coding

As planned, EPI-Info was used for data entry. However despite all efforts nobody of NETWAS survey team had learned to use EPI-Info which left the design of the data entry forms to the author.

Data entry took two people more than a month, although this was as much due to lack of commitment and organisation. It is clear that data entry, for people not fascinated by the analysis, is a tedious, repetitive job. Numeric data entry with EPI-Info worked as expected, however it is doubtful that NETWAS would be capable of designing the entry forms themselves.

In relation to the unique form number the entry sheet in EPI-Info 2000 was so designed that it would check for existing numbers in its data base to avoid duplication of numbers. Unfortunately to speed up the process of data entry two computers were used and a file with 259 records and another with 460 records were merged. After the merge it became clear that the total records was 727 (not 719 as expected) and eight records had missing values for the form reference. This was a surprise as the entry sheet in EPI-Info 2000 was programmed so it should not accept any record without this value. Only a series of errors could make such an entry possible and doing this eight times in the same survey is worrying.

Using two computers that were not networked made it possible for the same number to be entered twice, once in each computers. This happened in more than 50 records. In all but one cases it was possible to attribute the number from the correct form number to the record by crosschecking the paper data but this was an even more tedious and time consuming activity than data entry itself. While some form numbers were not correctly coded no errors were found in the data that was recorded apart from some obvious mistakes of typing the time in minutes in the location for the hours and ignoring the warning which would have been given by the EPI-info entry sheet.

It was decided not to do double data entry. This was not because it was not considered useful or that few data entry errors were found initially, but mainly because the largest error was in the coding of the form numbers (the identifier for matching records). Also it would have required additional time and effort to build a suitable matching dataset. During the analysis, however, the error of this decision became clear.

The initial aim was to organise the surveys around the data entered. This meant coding household to survey entering data on non-response households. This required daily data entry which could not be maintained and a lot of work with little gain. Moreover the process of entering data is painstaking slow. It is clear from this experience that the survey has to be organised as much as possible on paper unless technology assisted data collection, such as the use of organisers, is possible. Lacking these, the data which is coded should be kept to a strict minimum and there should be a clear benefit for people to code the data right from the first time. It is also crucial that the unique identifier of the interview form is entered correctly. More convenient ways for data inputting should be found to avoid error at this point in the survey.

Use of 'other' in pre-selected answers

Early in the survey, 'over use' of "*other*" as an answer on multiple choice questions was noticed. This indicated that surveyor did no feel comfortable with the given set of answers in the questionnaire, or that interviewers were not properly trained in the classification of the answers. More importantly it indicates that contrary to what was initial thought there is a **level of judgment** from the surveyor in classifying the given answer on the survey sheet. The initial idea of coding '*other*' in the data base for recoding (Chapter 5) was quickly abandoned as it was time consuming to code these answers. When the *other* line was used the answer was often difficult to read. To avoid using *other*, individual debriefing with the surveyors at the end of each day included discussions on recoding *other* answers into the other options available. This resulted in reduced use of this option and only one occurrence into the final data set.

7.4.11 Data analysis

EPI info combined data to create the indicator values per record while the data was entered. When the data was later corrected the indicator values were not automatically updated. Post processing, which could solve this problem, was not possible in EPI-Info (Chapter6). After various failures to solve this within EPI-Info, data were converted to Stata to create the indicator and analyse the data.
Detailed analysis of the Kenya data can be found in Chapter 8.

7.5 Field survey in Thakhek District, Laos PDR

7.5.1 Introduction

The last of four surveys was conducted in Thakhek District of the Laos People's Democratic Republic between May and July 2003 by the '*Urban Research Institute*' (URI) of the Laos ministry of Communication, Transport, Post and Construction (CTPC) and the *'London School of Hygiene and Tropical Medicine'* (LSHTM). It was financially supported by the *'Energy and Water Department of the World Bank* (WB)*'* and locally backed by the WB's Water and Sanitation Programme for East Asian and the Pacific (WSP-EAP) regional office. This section is, as was with the Kenyan survey, entirely based on the author's experience of applying the *WaSH* survey methodology. This section concentrates mainly on methodological issues. More information on the survey itself can also be found in the Author's report to the World Bank in Annex J.

7.5.2 Aims of the survey

The general aims of the survey were to apply the survey methodology in an **Asian context**. The specific goals were to **measure** the ***deff*** and ***roh*** in a water and sanitation specific survey and to **validate** the WaSH indicators, in particular, the **hygiene indicator**. After the high population density in an urban area in the Kenyan survey a lower population density in a rural area was preferred. Laos has by Asian standards a very low population density of approximately 25 people/km^2, which is below average for rural areas when compared to urban areas.

7.5.3 Site selection

To find a suitable site for the trial a reconnaissance of potential places was carried out by the team coordinating the survey. Various districts in the central and southern regions of Laos PDR were considered such as:

- Paksan in Borlikhamsay province,
- Outhoumphone in Savannakheth province,
- Champasak, Phonethong,
- Pakse in Champasak province and
- Thakhek in Khammouan province.

Suitability criteria for a survey site were:

- availability of data to build a sampling frame for the whole survey area. This includes:
  - identification of individual households as BSUs and
  - identification of more than 32 primary sampling units.
- mainly a rural area with low population density.
- a variety of water sources used for drinking and washing.
- a variety of sanitation solutions applied in the survey area.
- clearly identified urban and rural areas.
- willingness of local authorities to collaborate.

Based on these criteria, Thakhek was selected for hosting the survey. Instead of concentrating only in the urban area of Thakhek as initially suggested by URI it was agree that the survey would cover the whole district.

7.5.4 Indicators

The questionnaire and indicators used in the Laos survey were not significantly different from those used in the Kenyan survey.

7.5.5 Sampling

At the start of the Laos survey the non-response rate was high and similar to that of the Kenya survey. By the time surveyors were in the field many people had already left for their paddy fields, usually with their whole family, and it was essential to get people out early in the day. After the first two days the crude non-response ratio was as high as in the Kenya survey. To combat this, the surveyors were convinced to start earlier (changing from 8am to 5 am) and finish later (changing from 5pm to 7 pm), thereby increasing work hours dramatically. Still only 998 interviews could be done from the 1024 planned interviews resulting in a crude non-response ratio of 2.5% (26/1024=2.5%).

Defining the population

The survey population households lived in Thakhek district in the Khammuan Province, situated in Central Laos (see Figure 7.5). The district contained 141 villages of which 29 are considered by the local authority to be urban. Based on the figures initially given by the 141 villages there are 15,145 households with a total of 78,577 people living in the district. 17 villages could not be reached within a day due to the rainy season[9] and had to be excluded from the survey which left **124 villages** to be included in the survey. The non-accessible villages contained 13.8% of the households and 13.3% of the Thakhek population. This difference is due to a slighter lower average household size of 5.0 pers./household in the inaccessible villages compared to 5.2 pers./household in the villages with access. Their inaccessibility for large parts of the year might make them different in regards to WASH compared to the households that are accessible whole year round. The possibility that these 17 villages can be different in terms of WASH should be taking into account when interpreting the result; even though survey organisers and local authorities familiar with these villages doubted that the difference would be significant.

[9] The rainy season was chosen because it was the moment URI was available for 'unplanned' activities. This choice should not affect the testing of the methodology and will have limited impact on the outcomes.

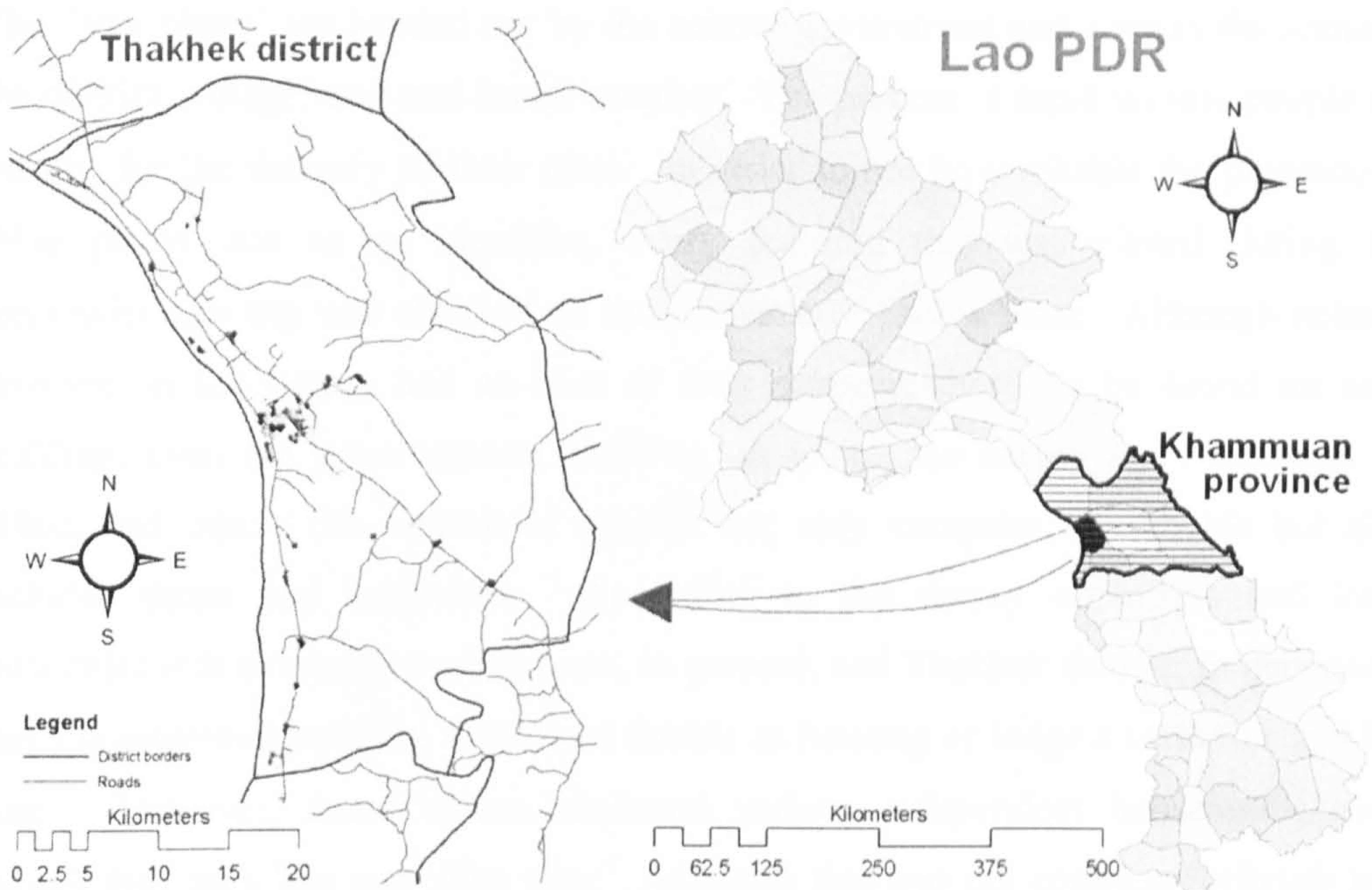


Figure 7.5: Thirty Two Selected Villages in Thakhek (coloured dots) and their location in Laos PDR

BSUs and PSUs

The definition for members of a household preferred by the survey organisers was *"people that slept under the same roof last night"*. The majority of houses in Thakhek district are traditional independent buildings on stilts which houses the whole household under one large roof. A unique identifier would be 'the blue plates' that each building requires.

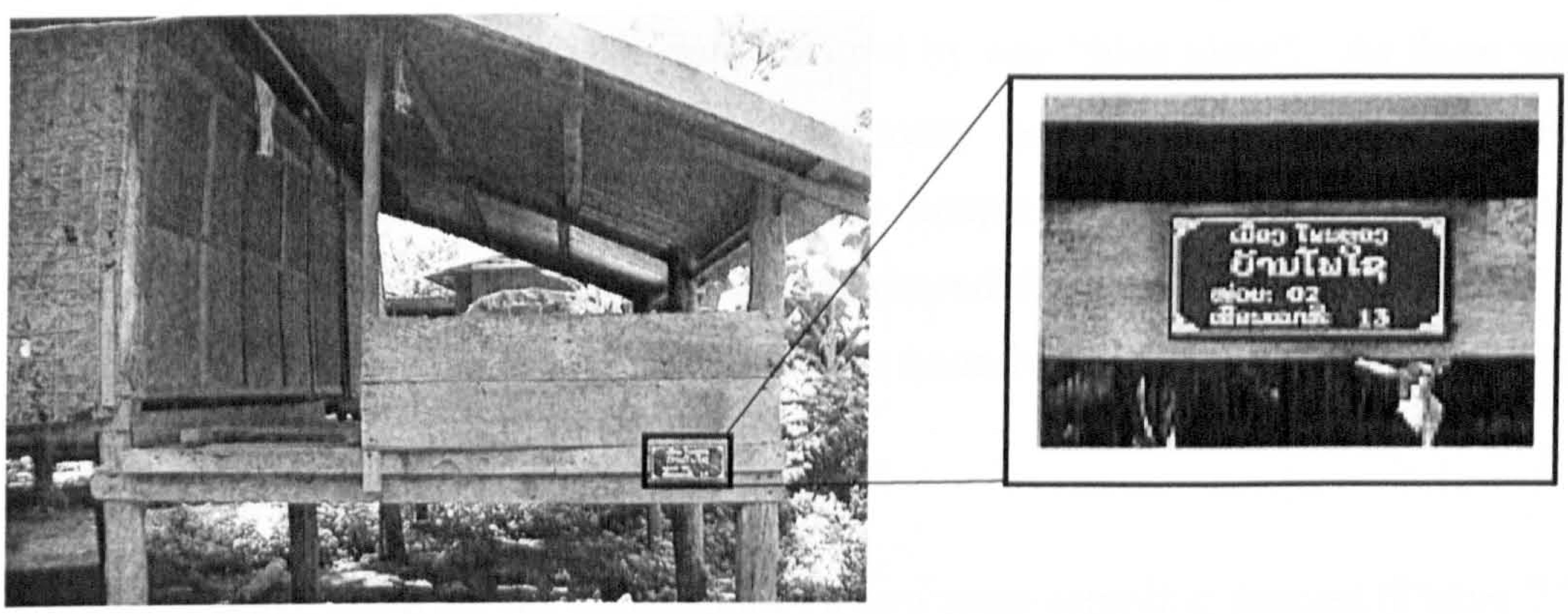


Figure 7.6: Household Registration Plate (The Blue Plate)

The 'blue plates' are handed out by the central government and contain the name of the district, village, unit and house number. The process is rapid so few people are waiting for the delivery of their plate. In order to see how reliable the presence of 'blue plates' are as an identifier, every building that was visited during the reconnaissance trip was checked on the presence of such a plate. Although nobody involved in the survey had an idea of their purpose, they can be found on each building, even the governmental building, in which the survey team obtained an office, had one. The household listings not only comprise households but also includes shops and businesses. According to the survey organisers and local authorities it is extremely rare in Laos, in general, and Thakhek district, in particular, that a commercial building would not double as housing or lodge a caretaker and his family. However, some houses sheltered various independent households, even though they only had one 'blue plate'. Although this was not common, officials had no accurate estimates how many of such cases existed in Thakhek district.
Despite the existence of these unique 'blue plates' which are provided by a central government to individual buildings, URI, the implementing research organiser, was not aware of these plates having ever been used for identification purposes in surveys. Nevertheless it was considered a feasible approach. The only alternative approach would be to make list of all households in each accessible villages in Thakhek district. This would not only be labour intensive but impossible to do within the time and budget granted for the survey.

Some days into the survey it was discovered that some longhouses which have multiple households in their unit were covered by one "blue plate". As there were few and no data was collected on how many households lived within these longhouses, no corrections were made in the sample weights. However until this realisation was made, the surveyors had interviewed the household of the 'leader' of the longhouse. This was changed to a random household in the longhouse to reduce possible bias.

Chapter 5 suggested a survey consisting of a two stage sampling process (Figure 7.7) in which the first stage is the selection of 32 PSUs, chosen with a probability proportionate to population in each PSU. In the Laos survey the PSU were determined by the villages' administrative borders. This resulted in 124 accessible villages from which 32 were selected with PPS as shown in Table 7.4.

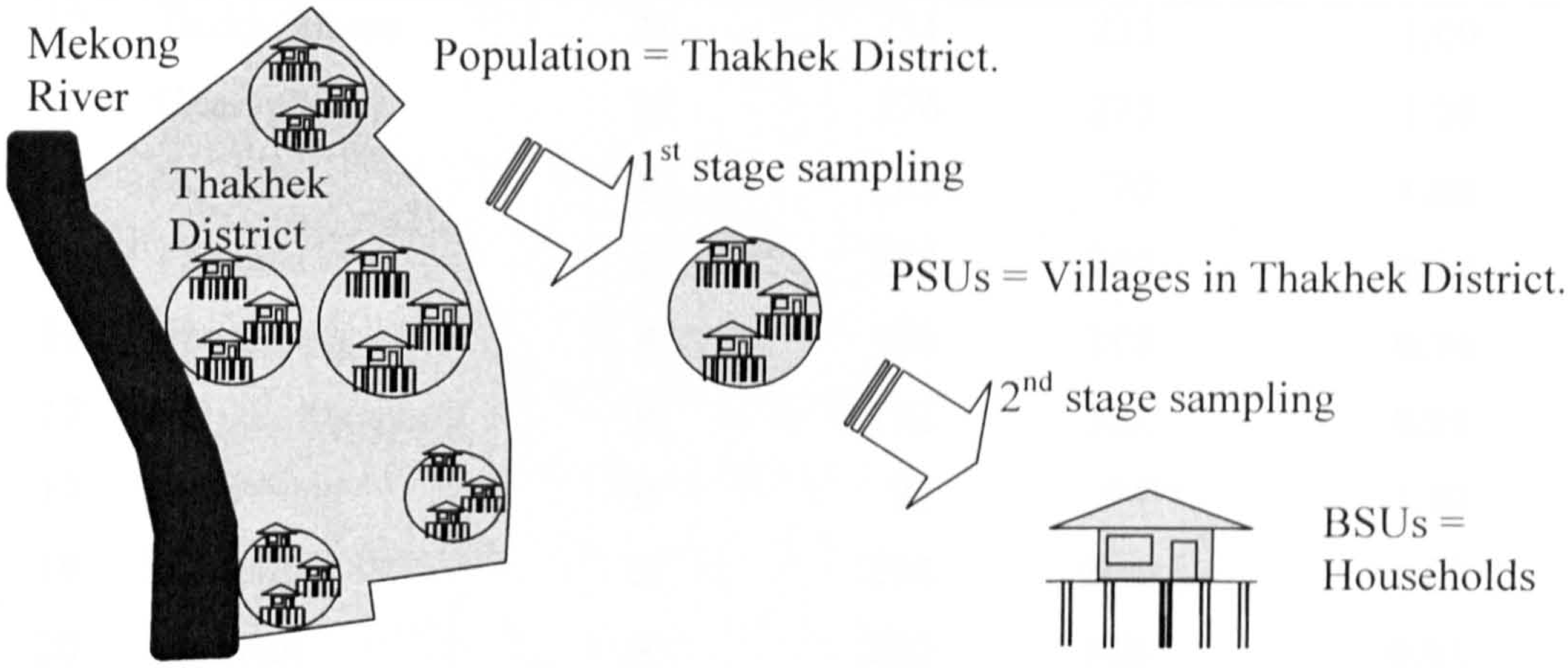


Figure 7.7: Two stage cluster sampling.

The second stage of the sampling process (Figure 7.7) is the random selection of 32 households in each of the 32 selected villages. An extra household was added to each of the clusters to compensate for possible non-response. This will increases the total sample size by 3% and resulted in a total sample size of 1056 households.

No:	Name of village	Urban/Rural	Number of households: Initial figure	Number of households: Updated (1) figure	corrective (2) weight for sample in PSU
1	Chomcheng	U	125	125	1.00
2	Chomthong	U	166	187	**1.13**
3	Nongbuathong	U	168	198	**1.18**
4	Dornkheuanxang	U	206	222	**1.08**
5	Somsanook	U	219	182	**0.83**
6	Phonesa-Aad	U	375	246	**0.66**
7	Phonesanam	U	285	316	**1.11**
8	Souksavanh	U	315	317	**1.01**
9	Viengvilay	U	302	279	**0.92**
10	Dornmuang	R	94	96	**1.02**
11	Thakhekkang	U	287	330	**1.15**

No:	Name of village	Urban/Rural	Number of households: Initial figure	Number of households: Updated [(1)] figure	corrective [(2)] weight for sample in PSU
12	Thakheknuea	U	231	231	1.00
13	Chomphet	U	276	275	1.00
14	Nongphue	R	65	70	**1.08**
15	Thaduea	R	284	266	**0.94**
16	Bunghieng	R	156	115	**0.74**
17	Dongkommaketh	R	192	182	**0.95**
18	Dorn-Ngai	R	92	94	**1.02**
19	Nabong	R	294	294	1.00
20	Pakpeng	R	200	186	**0.93**
21	Tatthong	R	56	50	**0.89**
22	Phone-Ngearnoi	R	143	125	**0.87**
23	Nadone	R	258	281	**1.09**
24	Thammalad	R	170	157	**0.92**
25	Dongmuangkhai	R	216	216	1.00
26	Taan	R	296	207	**0.70**
27	Tham	R	176	181	**1.03**
28	Maiphosi	R	53	60	**1.13**
29	Dorndone	R	87	87	1.00
30	Vearn	R	78	68	**0.87**
31	Nakaikhia	R	88	102	**1.16**
32	Hadkham	R	100	100	1.00
	TOTAL		6053	5845	0.97

1) Figures obtained when detailed household information was obtained from selected PSU's
2) Sample weight correction due to discrepancy in number of households / PSU explained below.

Table 7.4: Number of households for each of the 32 selected villages

As there was a discrepancy between the original figures and the later obtained figures it was considered worthwhile to see how much a correction factor on the probability of selection would change the access figures. The corrective weight in the last column of Table 7.4 was obtained as shown in Equation 7.2 below.

$$\left.\frac{\text{Updated household numbers}}{\text{Initial household numbers}}\right| = \text{corrective weighting for households in PSU}$$

Equation 7.2: Corrective weighting for households in selected PSU

A corrective weight higher than one (blue in Table 7.4) indicates that the result of the cluster should be more important than initially considered when the PSU was selected. Figures less than one indicates that weighting was originally too high while weights higher than one indicated households were under weighted. The biggest discrepancy was found in Phonesa-Aad which reported initially 34% more households than they could list when submitting their detailed household listing. There could be many reasons for this difference in the number of repeated households. One could be that initial lists are based on out dated data and updated figures were received when a list of all the households in the village was required. Villages where also explicitly asked to include households that did not have a 'blue plate' and to divide those houses that had one plate but contained a number of different households as they were defined above. Assuming that the above assumption would be correct the overall reduction of the number of households in the Thakhek district (based on the 32 PSU in Table 7.4) is in line with the statistical office statistics which indicate that emigration from the Thakhek district to the larger urban conurbations is larger than population growth and immigration together. Not enough information is available to attribute the total difference in number of households in Table 7.4 with any certainty to migration alone.

The above procedure assumed that **all** the people in the district were part of a household that was registered in one of the district's 141 villages. It also assumed that each household was only registered once. Neither of these assumptions could be checked at the time.

Practical implementation

Survey staff

The survey was coordinated by three senior URI staff who were advised by the author. The survey team consisted of 16 surveyors of which 10 were URI staff, three from Thakhek department of CTPC and three from the Thakhek Urban Development Administration Authority (UDAA). The survey team was divided into two groups; six people in the survey or interview group and a further 'observer group' of 10 people whose task was validation.

Collaboration with local authorities

During the preparations in Vientiane, the survey plans were extensively discussed with:

- the National Centre for Environmental Health and Water Supply (Nam Saat) which is part of the Ministry of Health (MoH);
- the Water Supply Authority (WaSA);
- National Statistical Centre (NSC);
- WSP-EAP and other organizations.

This allowed the team to collect results from former surveys, details on definitions used where available, and other information and advice for the survey.

During the field survey, the survey team worked closely with Thakhek (UDAA), Thakhek DCTPC, the Provincial Administrative Office and other local authorities such as district office, village elders and village heads. The survey team was given temporary office space in DCTPC offices for data coding, meeting and daily survey preparation work.

At the start it was made clear that this survey was not linked in any way with possible future interventions. Despite this, there was a high level of cooperation and a clear interest from the authorities in the survey.

Training for the surveyors

Prior to the survey a three-day training course of interviewers and observers was organized. Despite differences in training needs, both groups were trained together. This was partly because of the lack of an experienced observer to prepare a separate training and partly because the survey organisers decided that observers, who would only carried out observations until 13:30, would conduct interviews following their daily observation.

Although this saved time and money it proved a problem for the quality of the surveys conducted as will be discussed in Chapter 9.

The training had the following goals:

- give the participants a history of the project and its relationship with the MDGs;
- outline problems regarding current monitoring of water, sanitation and hygiene behaviour;
- outline goal and methods in the WASH survey methodology;
- highlight activities involved in validating the methodology;
- promote discussion on the methodology as it stands and suggestion for changes;
- practical sampling issues;
- translation of the questionnaire into Laos (and back to English as a check);
- discuss how to behave and problems that might be expected while doing a survey;
- carry out role-plays of doing the survey and simulating potential problems;
- training on the use of a GPS;
- pilot testing of the questionnaire.

The core of the training was the discussion, translation and piloting of the questionnaire. It was clear that most nuances in the English questionnaire were quickly lost in translation. Laos translations which resulted in almost perfect English questionnaires when translated back to English proved to be useless to the survey. It was more useful to explain the exact goal of the question and explain each answer carefully than to work with literal translations. This also allowed discussion of any plausible answers not represented in the questionnaire, as these might result in the wrong classification of the household if the interviewer is not aware of the issues being addressed.

Spot observations, as used in the survey, are the hardest to standardize between different surveyors and between surveys. For the present survey, this 'standardization' was done by clear descriptions, definitions and visiting all the toilets in the DCTPC compound. In future this could be extended to the use of photographic training materials adapted to the local situation.

The quality of the training will also depend on the training experience and capacity of the organization, but three days seems to be the minimum duration required. During the survey, it takes around three days in addition to the three training days for people to become familiar with what is required. As the data collection takes 10-12 days this is almost one-quarter to one-third of the survey period. Therefore, there is an advantage in doing several surveys with the same team to benefit from their experience and to spread the training cost over several surveys. If time and resources allows, it might even be better to organise the survey so the data collected during the first three days is disregarded.

Training can be made easier, once the *WaSH* methodology is finalized, by designing adequate generic training materials.

Data entry

To speed up the process of data entry three computers were used and the three files merged. This meant that there was the possibility of the same number being entered in each of the computers. The Laos dataset suffered from duplicated form numbers which had to be solved before the three data sets could be merged. However the Author was better prepared for this and it took less time to clean the data set. Particular attention was paid to matching those household which had undergone the survey with their observation, as this was essential to the observation. Forms used in the Laos survey can be found in Annex K.

The next chapter will analyse the data from the Kenya and Laos survey and validate the survey data with the information obtained from observations.

CHAPTER 8 ANALYSIS AND VALIDATION OF DATA AND METHODS

8.1 Introduction

The previous chapter provided a narrative on four of the *WaSH* trials, highlighting some of the problems encountered while implementing the survey methodology. This chapter analyses the data collected in the two trials, Kenya and Laos, for which data sets were available for analysis. Although some analyses in this chapter give information on the target population, the chapter's major aim is documenting the methodology.

The chapter first looks at response and non-response in the surveys before the data are analysed. These analyses include the calculation of *WaSH* indicators in both surveys, testing of the sample frame, and determining *deff* and *roh* as well as the validation of the indicators. The results of this analysis will be discussed further in Chapter 9 which evaluates the *WaSH* survey methodology.

8.2 Response and non-response

Before analysing the collected data it is worth looking at which of the selected households responded and more importantly, those which did not respond, because the difference between them could lead to biased results. The formulae used to determine the level of response and non response, used below, was first introduced in Chapter 6, required extending the different response and non-response categories to adapt the analysis to a more complex reality. At the end of this section the potential problems of non-response bias for this survey are described, rather than actively correcting for potential bias as suggested in Chapter 6.

8.2.1 Respondents in the Kenyan trial

In the Kenya survey only 727 households were visited by interviewers, compared to the 1024 households targeted (page207). The difference is due to the change in sampling design from a clustered random sample design to a simple random sampling design requiring fewer households. A high non-response rate resulted in up to three visits to households which stretched the survey team's capacity and made it impossible to interview more households.

From the 727 households visited, only 411 could be interviewed, as illustrated below. This resulted in a crude non-response rate of 57% =411/727.
The categories used in Table 8.1 are adapted from those used by the American Association for Public Opinion Research (AAPOR).

Cat.	Respondent	*n*	Percentage (%)
0_a	Preferred (female)	308	42
0_b	Not-preferred (male)	98	14
0_c	Unknown	5	1
	Total	411	100

Table 8.1: Classification of respondents in Korogocho

Although preference was given to 'the woman of the house' to represent the household, the interviewee was often a male. Out of the 406 interviewed households for which gender information is available, 98 (24%) were male. Unfortunately, none of the information collected enabled assessment of whether in these 98 cases a female representative of the household was available during the interview.
To assess whether there was a measurable difference in response between male and female respondents a logistic regression analysis was used with as null hypothesis (H_0), that the differences between both groups was only due to chance (Table 8.2).
In Table 8.2 the hygiene behaviour indicator is excluded because it contained pocket-voting in which household members of different gender participated. Although the *p*-value was similar for the hygiene behaviour indicator, it would be illogical to attribute this response to the gender of the main respondent.

Outcome of interest (*WaSH* indicator)	*n*	*p*-value (logistic regression)
Access to an 'improved' water source	389	0.77
Access to 'improved' sanitation	381	0.68
Water an sanitation combined	381	0.81

Table 8.2: Likelihood that *WaSH* indicators are pre-determined by the gender of the respondent.

Table 8.2 shows that contrary to expectations no significant differences in outcomes were measurable in responses by gender. *WaSH* indicators in this trial seem not to be significantly affected by the respondent's gender. This was contrary to expectations based on information given by fieldworkers, who indicated that men and children seem to be more willing than women to admit to unimproved hygiene behaviour (not shown in Table 8.2), such as non-use of sanitary facilities or failing to wash their hands at critical moments.

8.2.2 Non-response in the Kenyan trial

The low response rate was partially due to errors in the sample frame as well as the difficulties in finding and correctly identifying compounds. To compensate for this, surveyors received a supplementary list of households (Chapter 7).

The categories (Table 8.3) used for analysis of non-response are based on the RR5 method of the AAPOR 2000 standards used in the DHS surveys .

Cat.	Reason for non-response*	*n*	Percentage of non-response†		Percentage of total sample
1	Nobody present	141	45%	[73%]	19%
2	Destroyed / Abandoned	36	11%		5%
3	Not located (Does not exist?)	19	6%	[8%]	3%
4	Vacant/people left for long time	25	8%		3%
5	Changed from domestic function	41	13%		6%
6	Under construction	8	3%		1%
7	Risky/hostile/unwilling	16	5%	[8%]	2%
8	Repeats (been visited before)	10	3%		1%
9	Reason missing on survey form	20	6%	[10%]	3%
10	Household listed but not visited	0	0.0%		0.0
	TOTAL	316	100%	[100%]	43%

* Categories adapted from (AAPOR) 2000 standards

† In [%] are the values for the 'true' non-response categories considered in Equation 8.1.

Table 8.3: Various non-response categories in Kenyan survey

Response and Non-Response categories as used in Table 8.2 and Table 8.3 are classified in Box 8.1 an the non-response rate calculated in Equation 8.1 on page 276.

0. Interview completed with:
    a. prefered representative of the household
    b. not-preferred representative of the household
1. Nobody present

   No household member available for an interview at any recall visit
2. Destroyed / Abandoned

   This category represents an error in the updating of the sample frame but can not be considered non-response as there are no valid BSU's that were missed.
3. Not located (Does not exist?)

   Initially 'not located' and 'does not exist' were kept together in one category. However this was a mistake as it is not because the household was not located that it did not exist, so it is not possible to exclude this category from non-response with certainty.
4. Vacant / People left for a long time

   Some household members return to rural areas for an extended period such as during harvesting or for other activities. During that time they cannot be considered to be part of the sample frame and hence do not fall in the non-response category. This classification of response rates is in line with the RR5 method of the American Association for Public Opinion Research (AAPOR) 2000 standards. It slightly overestimates the response rate as some people classified in this group might be eligible for inclusion in the sample and if so would be non-respondents.
5. Changed from a domestic function to a non-domestic function.

   Some rooms had become shops of various kinds and one had become part of a church. These are errors of the sample frame and not included in the calculation of the non-response rate.
6. Under construction

   This also constitutes an error in the sample frame hence its exclusion as a non-response error.
7. Risky / Hostile / Unwilling

   This category includes all non-responses due to insecurity or lack of cooperation. Most common were people unwilling to interrupt their daily chores to be interviewed.
8. Repeats (been visited before)

   These are errors in the way the sampling is run and cannot be considered as non-responses.
9. Reason missing on survey form

   As it is not known what the reason was it will be assumed they are part of the non-response group
10. Household listed but not visited.

    Fortunately this did not happen during the survey but would not have been considered a non-response.

Box 8.1: Classification of response and non-response categories as used in the *WaSH* survey trials

Some partially-completed survey forms were classified as *unwilling* after the respondent declined to finish the interview. So categories 1,3,7,9 in Table 8.3 can be considered as 'true' non-responses. Calculation of the non-response rate (NRR) as shown in Equation 8.1 below shows that one in every five households sampled resulted in non-response.

Although the NRR of 25% calculated by Equation 8.1 is high, it less than the 57% crude non-response rate calculated earlier. With such a large portion of the sample not responding, the main question is whether these non-respondent households are significantly different from others in regard to the *WaSH* indicators.

Non-response rate:

$$NRR = \frac{[1]+[3]+[7]+[9]}{[0_a]+[0_b]+[0_c]+[1]+[3]+[7]+[9]} = \frac{141+19+16+20}{308+98+5+141+19+16+20} \cong 21\%$$

Categories $[0_{a\text{-}c}]$ are taking from Table 8.2 and
Categories [1-9] are taking from Table 8.3 while all categories are explained in Box 8.1

Equation 8.1: Non-response rate (*NRR*) in Kenyan survey

Without being able to measure the problem, fieldworkers estimated that that around one fifth[1] of the total households not interviewed were single men working as casual labour[2]. These men are considered among the poorest in the settlement, leave early in the morning and come back late in the evening, working six to seven days a week. This could explain why they were not available during the survey. If a considerable part of the non-respondents are single men or some other anomalous group, they could bias results because:

- The survey assumes that the household sizes are on average similar (no sample weighting, Chapter 5) and indirectly assumes that this average size is the same in response and non-response categories.
- If a particular type of family, in this case single male households, are excluded from the sample through non-response, this might bias the sample towards other types of households.

1 This would indicate that over 0.5% of the total households in Korogocho would be single men. According to various people active in Korogocho, this is a plausible estimate.

2 Or 1 in 4 of the "true" non-respondent used in Equation 8.1

- If these households (different types or different size households) are different in regard to the measured outcome this could lead to a biased result.

This potential non-response bias should be evaluated together with the potential coverage bias highlighted in Chapter 7. As there was no opportunity to assess the possible extent of any bias, it could only be documented as suggested in Chapter 6.

8.2.3 Response in the Laos trial

To compensate for non-response, the sample in the Laos survey was increased by one household in each cluster. This allowed for 3% loss by non-response without significantly increasing the design effect. The response rate in Laos was higher compared to the Kenya survey. This was not only due to more attention invested in obtaining a higher response rate (Chapter 6), but also mainly because of the existence of more favourable conditions. As in Kenya, preference was given to females representing the household in the questionnaire.

	Adult	'Children	missing value	TOTAL
Male	507 (51%)	5 (1%)	3 (0%)	515 (52%)
Female	466 (47%)	13 (1%)	2 (0%)	481 (48%)
Missing value	0 (0%)	0 (0%)	2 (0%)	2 (0%)
TOTAL	973 (97%)	18 (2%)	7 (1%)	998 (100%)

Table 8.4: Maturity and gender of respondents in Laos survey

In the Laos survey it was more often a male (52%) that represented the household in interviews. In addition to 'gender' this survey collected information on the 'maturity' of the interviewer by dividing the interviewees in two groups 'Adults', ≥18 years, and 'Children' <18 years (Table 8.4).

Cat.	Respondent	n	Percentage (%)
0_a	Preferred	466	47
0_b	Not-Preferred	525	53
0_c	unknown	7	1

Cat.	Respondent	n	Percentage (%)
	Total	998	100

Table 8.5: Classification of respondents in Thakhek survey

The preferred respondent was a female adult person shown as shaded in light green in Table 8.4 while the not-preferred respondents are shaded in dark orange. This classification led to Table 8.5.

Determining if there was a measurable difference in outcome between 'preferred' and 'not-preferred' respondents, a logistic regression with *WaSH* indicators as outcome showed no significant difference between preferred and not-prefered respondents (Table 8.6).

Outcome of interest (*WaSH* indicator)	n	p-value logistic regression
Access to an 'improved' water source	981	0.87
Access to 'improved' sanitation	993	0.87
Water and sanitation combined	993	0.99

Table 8.6: p-values for H_0 in relation to the respondent being ideal or not ideal.

Similar analyses to determine if gender or maturity (Table 8.7) was significantly associated with *WaSH* outcomes could not find any indication for such. One reason this could be the small number of 'children (5♂, 13♀) to measure a significant difference rather than a lack of difference in their responses as p-values indicate (Table 8.7).

Outcome of interest (*WaSH* indicator)	n	p-value logistic regression
Access to an 'improved' water source	979	0.06
Access to 'improved' sanitation	991	0.40
Water and sanitation combined	979	0.10

Table 8.7: p-values for H_0 in relation to the maturity of respondents

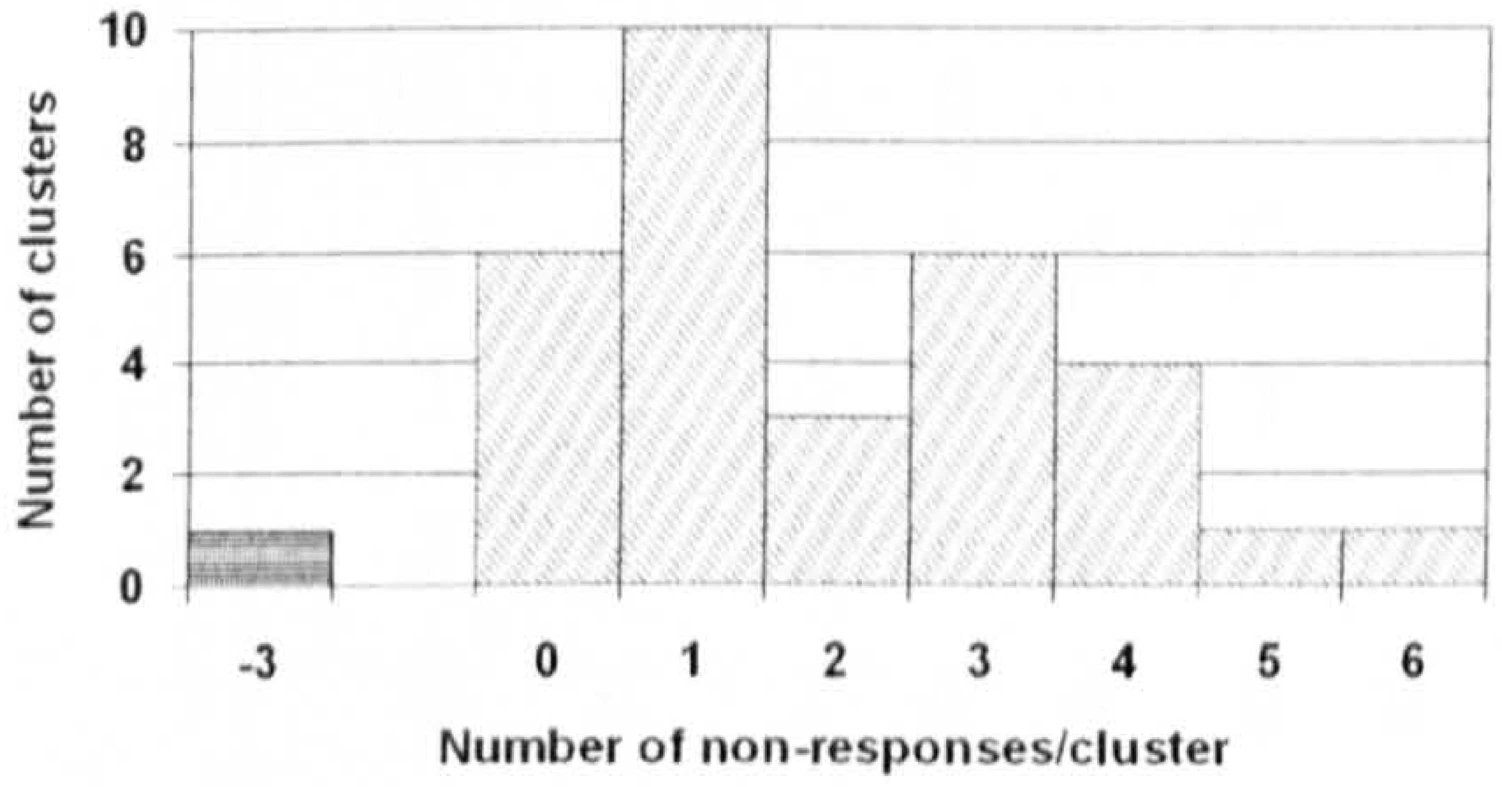
8.2.4 Non-response in the Laos trial

After three visits, all 58 non-responding households fell in the first category "*nobody present*" (category [1] in Table 8.3). The most probable reason was that the whole family were working in their paddy fields, but this could not be confirmed for most households. As in the Kenya survey, non-response rate can be calculated as:

$$NRR = \frac{[1]+[3]+[7]+[9]}{[0_a]+[0_b]+[0_c]+[1]+[3]+[7]+[9]} = \frac{58+0+0+0}{466+525+7+58+0+0+0} \cong 5.5\%$$

Equation 8.2: Non-response ratio (*NRR*) in Laos survey

This would mean that in order to compensate for losses in non-response compared to the original sample size of 1024, an extra 26 x 1.055= 27.4 households should have been included in the sample (two per cluster) which would result in 32 x 34 = 1056 instead of the 1024 as calculated in Chapter 5. This assumes, wrongly, that the missing values are homogenously spread over the 32 clusters. Graph 8.1 is a histogram showing the number of clusters with each number of missing values. The seven green bars on the right of the histogram total 61 missing households which is three more than the 58 non-responses. (1x6)+ (1x5)+ (4x4)+ (6x3)+ (3x2)+ (10x1)+ (6x0)=61



Graph 8.1: Number of clusters versus non-response/cluster

On the other hand there was one cluster which had 36 households, three more (red extreme left bar of the histogram with value -3) than the planned 33 which is clearly due to an error inputting the data into the computer. Not surprisingly, this was the default cluster when entering data in EPI-info set automatically by EPI-info. Such imputation errors will be discussed in Chapter 9.

8.2.5 Potential response rate to schoolchildren's questionnaire in Kenya

No primary school children questionnaire was included in the Kenyan survey as few children were available to answer those questions in the Kosovo and South Africa trials. To get a better idea on the availability of primary school children, two questions were asked in the Kenyan survey "*How many children go to a primary school in this household?*" and "*How many of these children are here NOW!*"

Of the 411 interviews held, 408 contained information on primary school children Only 198 households had children that went to a primary school. From the 458 primary school children in interviewed households only 129 (28%) were available for interview in 63 (15%) households. In 46 households (23% of all the households having primary school children) all school children were available for interview while in 17 some primary school children were available.

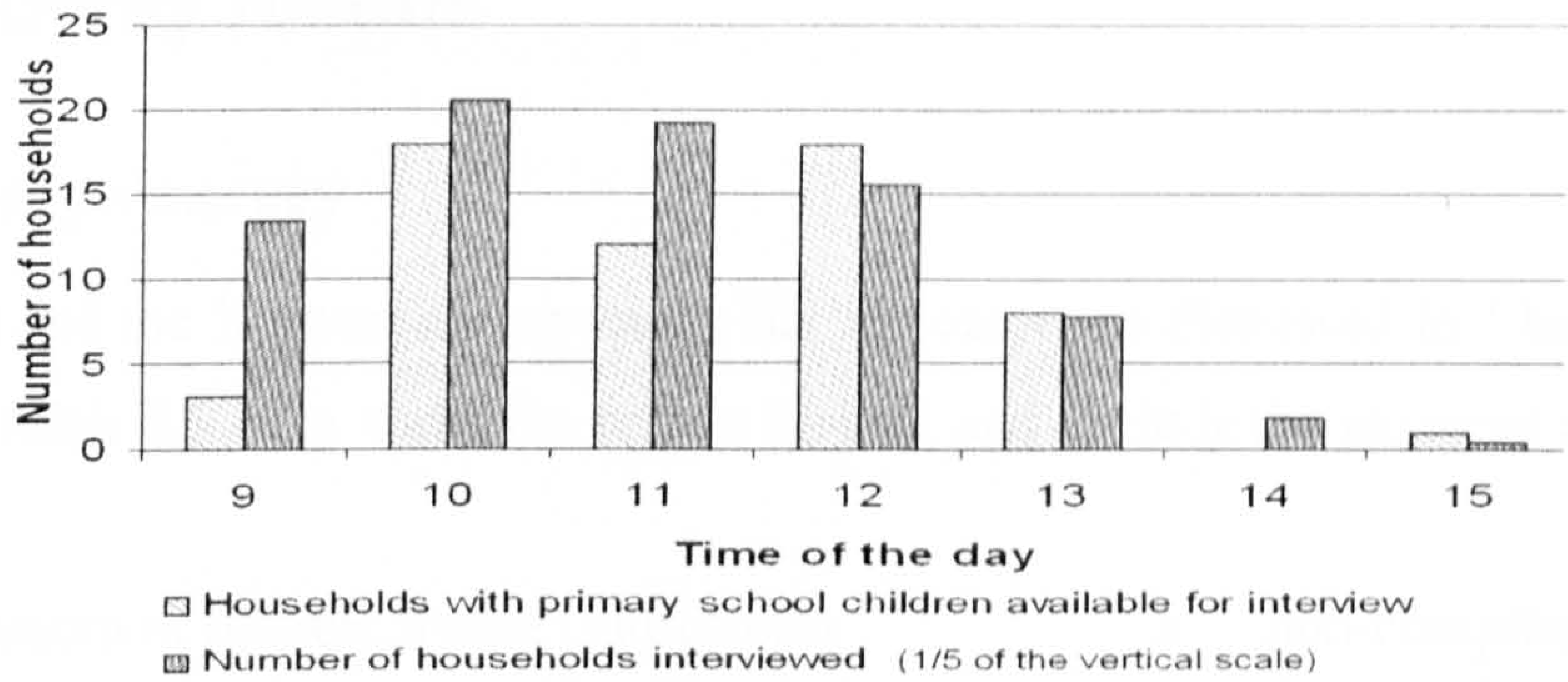
Primary school children in household \ Primary school children present for interview	0	1	2	3	4	5	6	total
0	**210**							**210**
1	45	**16**						**61**
2	44	4	**17**					**65**
3	32	3	2	**5**				**42**
4	8	2	1	1	**5**	1*		**18**
5	3	1	0	0	0	**1**		**5**
6	2	1	0	0	0	0	**2**	**5**
7	1	0	1	0	0	0	0	**2**
total	**345**	**27**	**21**	**6**	**5**	**2**	**2**	**408**

* Primary school child available but not part of the household visited

Table 8.8: Children available at the household during the interview

Having five to seven children that go to primary school in the same household seems high and these high values could be due to inputting errors[1].

The number of primary school children available at the time of interview is surprisingly high especially as the interviews did not only take place before school and during lunch break. As shown in Graph 8.2 the availability follows the patterns of the timing of interviews over the period of the day.



Graph 8.2: Availability of schoolchildren and time of interviews during the day

Out of 63 households which had primary school children available, 43 were interviewed at the weekend and almost exclusively on Saturday. This finding is more in line with the interest parents have shown in sending children to school after Kenya made primary education free for all Kenyans.

Information on the presence of school children at the household was omitted from the Laos questionnaire to reduce the number of questions and the amount of data to be entered into the survey database.

8.2.6 Non-response for the focus group discussion

In Kenya, initially 16 people were randomly selected from the 411 interviewed to take part in two 'identical' focus groups. Only 10 people were available to participate in the discussion, due mainly to some confusion about where and when people would meet. Many participants came too early and decided to leave when nobody seemed to be around to greet and brief them. It is difficult to assess whether those who left were in any way different from the people that were determined to stay, but it is likely that

1 For privacy reasons, survey forms were destroyed after February 2005 making verification impossible

information of interest is lost, particularly from those who live in a subsistence economy. In Laos the focus group discussion took a completely unexpected turn as explained in Chapter 7. However, in terms of non-representation, only one village of the 16 villages was not represented. The possible consequences of non-response in focus groups are raised in Chapter 9.

8.3 Survey results

8.3.1 Kenya survey

The results of the Kenyan survey using the indicators as discussed in Chapter 4 are shown in Table 8.9. For water the results include and exclude the payment criteria.

Measure of interest *WaSH* (indicators)	n	non-compliance
No access to 'improved' water (excl. payment)	404	68.6 ±4.5%
No access to 'improved' water (incl. payment)	409	95.8 ±1.9%
No access to 'improved' sanitation	391	88.5 ±3.2%
Not practicing 'improved' hygiene behaviour ①	382	69.1 ±4.7%
Not practicing 'improved' hygiene behaviour ②	411	23.6 ±4.3%
Not practicing 'improved' hygiene behaviour ③	386	65.8 ±4.8%

① Using the hygiene behaviour indicator as described in Chapter 4 (Cut-off >⅔)
② Using pocket voting only (Cut-off >⅔) to classify households
③ Using absence of soap, water or basin/tap to classify households

Table 8.9: Results for the *WaSH* indicators as measured during the Kenyan survey

Both rates are illustrated as there was some doubt regarding the interpretation of this information. Figure 8.1 shows the questionnaire item which elicited it. During the focus group discussion the question and its assumptions were debated. All participants seem to agree they would prefer to pay periodically a fixed price for water, whether weekly or monthly. But contrary to what was assumed in Chapter 4, pay-as-you-go did not, according to the participants, reduce water consumption. This assumption, not previously tested, seemed to be false in Korogocho. People involved in the discussion group did not consider that the cost of water was a major factor to constrain them from collecting water. This might indicate that the question was not useful in discriminating between households for which pay-as-you-go is or is not a constraint.

S17	Do you have to pay EACH TIME you fetch drinking water?		
Coding categories		Go To	Remarks
Yes. I get charged for each time I collect water.	1		Pay-as-you-go
No. I pay a periodical fee (e.g. monthly)	3		Pay a rate over a period
No. I pay nothing at all	5		Free water supply

Figure 8.1: Question on water payment method used by the household in the Kenya survey

In the Laos survey this information was obtained through a differently formulated question discussed later.

Table 8.9 indicates that more than half of the Kenyan survey population had no access to water. The reasons for this are listed in Table 8.10, excluding the above-mentioned payment criteria, and in Table 8.11, which includes the payment criteria. From Table 8.10 it is easy to determine that only 2% are classified as not having access, due to the type of source. This is because most households use piped water from kiosks. Water collection time is a contributing factor to non-access in 15% of the cases. The biggest determinant for not having access to water in Korogocho according to *WaSH* indicators is an intermittent water supply, which affects 95% of the households interviewed. This means that for 95%, there was at least one day in the last seven when they could not collect water.

Rules	(% of households affected)	% of households
(1) Type of water source	(2%)	0.4
(2) Water collection time	(15%)	4.3
(1) and (2)		0.4
(3) Intermittent water source	(95%)	83.4
(1) and (3)		1.4
(2) and (3)		10.1
Total (n=404)		100.0

Table 8.10: Reasons for households 'not' having access to water in Korogocho (excl. Payment)

Doing a similar analysis including the payment criterion Table 8.11 shows that 2% are classified "non-access" because of the type of water source, 10% because of collection time, 67% because of intermittent supply and 92% because they had to pay for the water each time the household collected it.

Rule	(% of households affected)	% of un-served households
(1) Type of water source	(2%)	0
(2) Water collection time	(10%)	0
(3) Intermittent water source	(67%)	6.6
(1) and (3)		0.3
(2) and (3)		1.0
(4) Pay as you go	(92%)	29.3
(1) and (4)		0.3
(2) and (4)		3.0
(1) (2) and (4)		0.3
(3) and (4)		52.3
(1) (3) and (4)		0.8
(2) (3) and (4)		6.1
Total (n=409)		100.0

Table 8.11: Reasons for households 'not' having access to water in Korogocho (incl. Payment)

Water		JMP indicator		
	n=402	'access'	non-access	total
WaSH indicator	'access'	32 %	0 %	31 %
	non-access	67 %	1 %	68 %
	total	99 %	1 %	100%

Table 8.12: Access to an 'improved' water source according to JMP and *WaSH* indicators

Table 8.12 compares the water indicator as it is currently calculated by the JMP (Chapter 3) to the figures obtained by the *WaSH* indicator (Table 8.9) results. The JMP definition is in this eaxample identical to the type of source criteria (1) in Table 8.10 so these figures are used in Table 8.12 to represent the JMP values.

For the *WaSH* sanitation figures found in Table 8.9 the breakdown of reasons can be found in Table 8.13. As there are 5 'rules', 31 combinations are possible of which 27 were present in the survey.

Rule	(% of households affected)	% of households
(1) Type of toilet unsatisfactory	(31%)	4.2
(2) Public toilet	(64%)	4.5
(1) and (2)		4.2
(3) Type of payment	(34%)	0.3
(2) and (3)		6.4
(1) (2) and (3)		0.0*
(4) Unhygienic toilet	(45%)	13.4
(1) and (4)		5.1
(2) and (4)		4.2
(1) (2) and (4)		3.4
(3) and (4)		0.9
(1) (2) (3) and (4)		0.6
(5) Non-use of facility	(50%)	3.4
(1) and (5)		2.2
(2) and (5)		3.9
(1) (2) and (5)		2.0
(3) and (5)		0.0*
(1) (3) and (5)		0.0*
(2) (3) and (5)		6.4
(1) (2) (3) and (5)		3.1
(4) and (5)		3.4
(1) (4) and (5)		1.4
(2) (4) and (5)		6.4
(1) (2) (4) and (5)		2.8
(3) (4) and (5)		0.6
(2) (3) (4) and (5)		14.2
(1) (2) (3) (4) and (5)		2.0
Total (n=391)		100.0

* Combination is present in the survey

Table 8.13: Reasons for households as not having access to sanitation in Korogocho

The main reason for not having access to sanitation (affecting 65% of the households) is the use of public toilets. Non-access due to type of toilet is only applicable in 31% of the households. The JMP uses only 'type of toilet' to determine access. Comparing the *WaSH* indicator with the one used by the JMP shows significant differences in the access figures.

sanitation		JMP indicator		
	n=386	'access'	non-access	total
WaSH indicator	'access'	12 %	0 %	12 %
	non-access	61 %	27 %	88 %
	total	73 %	27 %	100 %

Table 8.14: Access to 'improved' sanitation according to JMP and *WaSH* indicators

JMP states that toilets should be private but does not takes this into account when measuring access figures due to the lack of such information. If this criterion was added to the JMP definition, the proportion in Table 8.14 would change dramatically as shown in Table 8.15.

sanitation		JMP indicator		
	n=386	'access'	non-access	total
WaSH indicator	'access'	1 %	11 %	12 %
	non-access	7 %	81 %	88 %
	total	8 %	92 %	100 %

Table 8.15: Access to sanitation according to 'JMP incl. private' and *WaSH* indicators

Comparing *WaSH* access to water and sanitation respectively (Table 8.16) shows that the two indicators are independent. For example only one-third of the people having access to sanitation also have access to water, while 13% of households with access to water have access to sanitation.

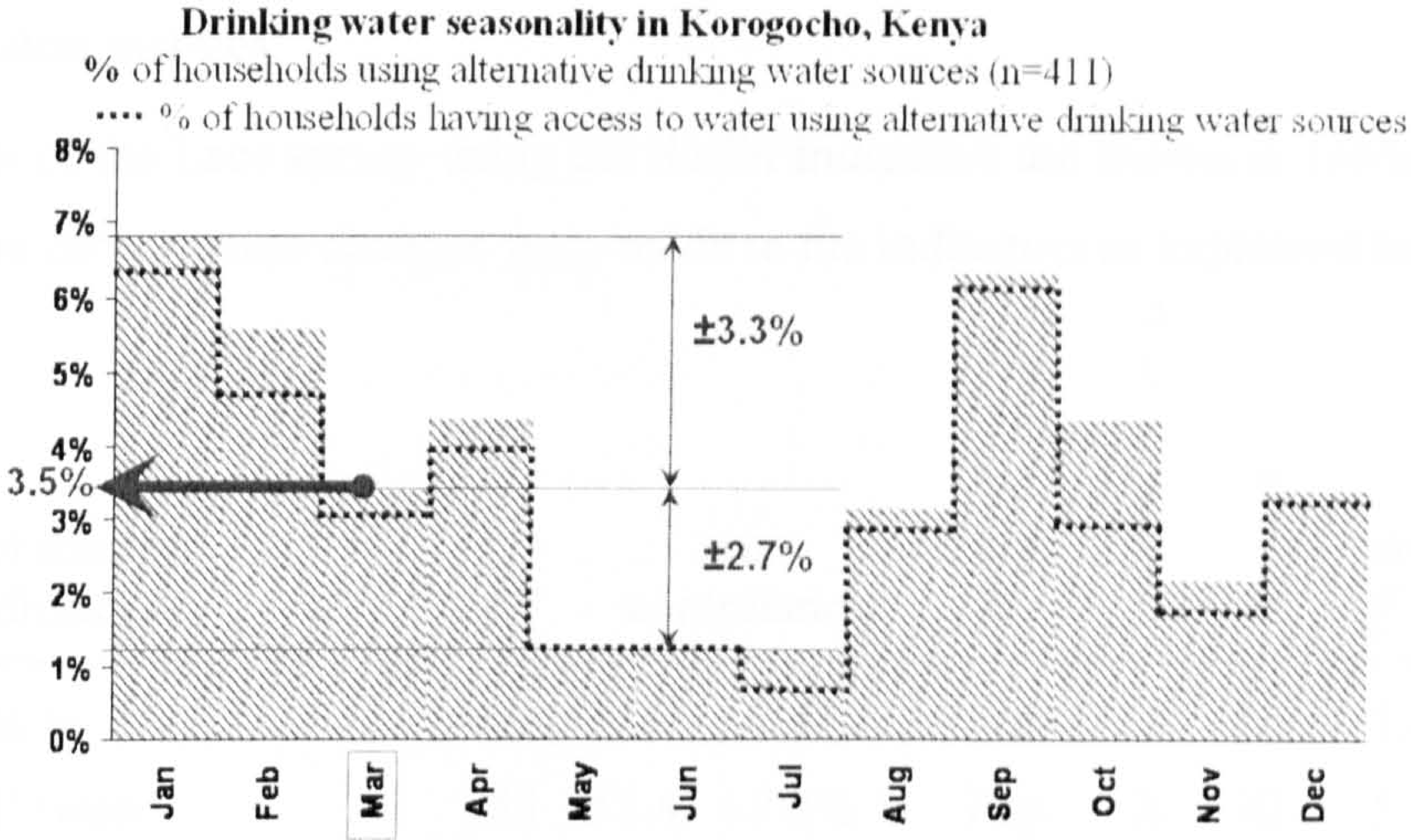
WaSH indicators	Access to Sanitation		
Access to water n=384	'access'	non-access	total
'access'	4 %	26 %	30 %
non-access	8 %	62 %	70 %
total	12 %	88 %	100.0 %

Table 8.16: Cross table of *WaSH* access to water and sanitation

One of the main problems with cross-sectional surveys is that they only give a snapshot of the situation at the moment of the survey. To see how access fluctuated over the year, households were asked in which months the source mentioned was not available. Graph 8.3 shows by month the proportion of households using an alternative water source to the one used the day before. This graph indicates how seasonally-dependent the collected data are. In March, the month in which the survey data were collected, 3.5% of households indicated that the source used the previous day was not the one they used throughout the whole month. As the dotted line indicate, most of the people who had 'changed' their water source had been classified as having access to an 'improved' water source.

The highs in the graph seem to coincide with the end of the 'dry' season following the seasonal rain pattern in Nairobi. It had not rained in the weeks before and during the survey, despite it being the rainy season.

Graph 8.3 indicates that the results for drinking water sources are representative for the most of the year (except Jan. and Sept.) as the seasonal variations are of the same order as the confidence interval of the estimate in Table 8.9. Access to sanitation and hygiene behaviour might also undergo seasonal changes, but it was considered less likely in comparison to water supply. However no data were collected to validate this assumption.



Graph 8.3: Seasonal variation in use of alternative drinking water sources in Korogocho, Kenya

The first results on hygiene-behaviour ① in Table 8.9 were calculated on six aspects of the hygiene-behaviour. Data had to be available on at least three aspects of the indicator and one-third or more had to be 'bad practices' before the household was classified as not practising 'improved' hygiene behaviour. If the cut-off point were one-half the proportion of the households not practicing 'improved' hygiene behaviour becomes 18.5±3.7% compared to 69.1±4.7% in Table 8.9. The problem of setting these cut-off values is discussed further when presenting the Laos survey results.

The second hygiene behaviour indicator ② in Table 8.9, based on pocket voting, required at least three of the four 'questions' to be answered regardless of the number of participants. Initially there had to be at least three participants for the pocket-voting but this resulted in 399 missing values as many households had only one or two people available to participate in the voting.

The third hygiene indicator ③ uses spot observation to assess whether:

- water for handwashing,
- soap or any other cleansing material,
- and a basin, tap or sink,

was available for handwashing. If either of the items were not available within the period of a minute, the household was classified as not practising 'improved' hygiene behaviour.

8.3.2 Laos survey

The results of the Laos survey using the *WaSH* indicators are shown in Table 8.9. In the Laos survey some changes were made to the indicators as explained below.

Measure of interest *WaSH* (indicators)		n	non-compliance	Weight	Strata	PSU	*deff*	*roh*
Non-access to 'improved' water		985	55.7 ±7.4%	All	2	32	5.2	0.14
		985	55.4 ±7.2%	Pop	2	32	5.1	0.14
		985	55.4 ±11.4%	Pop	1	32	12.5	0.39
		985	55.8 ±7.1%	None	2	32	4.8	0.13
		985	55.8 ±11.3%	None	1	32	12.2	0.38
Non-access to 'improved' sanitation		997	59.5 ±8.3%	All	2	32	7.9	0.23
		997	59.1 ±8.8%	Pop	2	32	7.6	0.22
		997	59.1 ±10.5%	Pop	1	32	11.1	0.33
		997	59.8 ±8.5%	None	2	32	7.2	0.21
		997	59.8 ±10.2%	None	1	32	10.3	0.31
Non-practising of 'improved' hygiene behaviour	①	998	28.4 ±4.9%	All	2	32	3.0*	0.10
	②	995	6.4 ±2.3%	All	2	32	2.8*	0.06
	③	997	69.7 ±4.8%	All	2	32	2.8*	0.06
	④	997	80.1 ±4.3%	All	2	32	2.0*	0.00

① Indicator used as described in Chapter 4 using all information except pocket voting
② Indicator depending on pocket voting only
③ Indicator depending on spot observations of handwash items only
④ Indicator depending on spot observations of handwash items minus soap or other cleansing agent
* Without stratification the *deff* varies between 5.9-6.6 for all 4 variations of the hygiene indicator

Table 8.17: Results for the *WaSH* indicators as measured during the Laos survey

Reasons for the non-access to water prevalence in Laos survey are listed in Table 8.18

Rule	% of households affected
Type of water source	55.8%
Water collection time	1.6%
Intermittent water source	0.5%
Cost of water	1.5%
Total (n=1002)	55.8

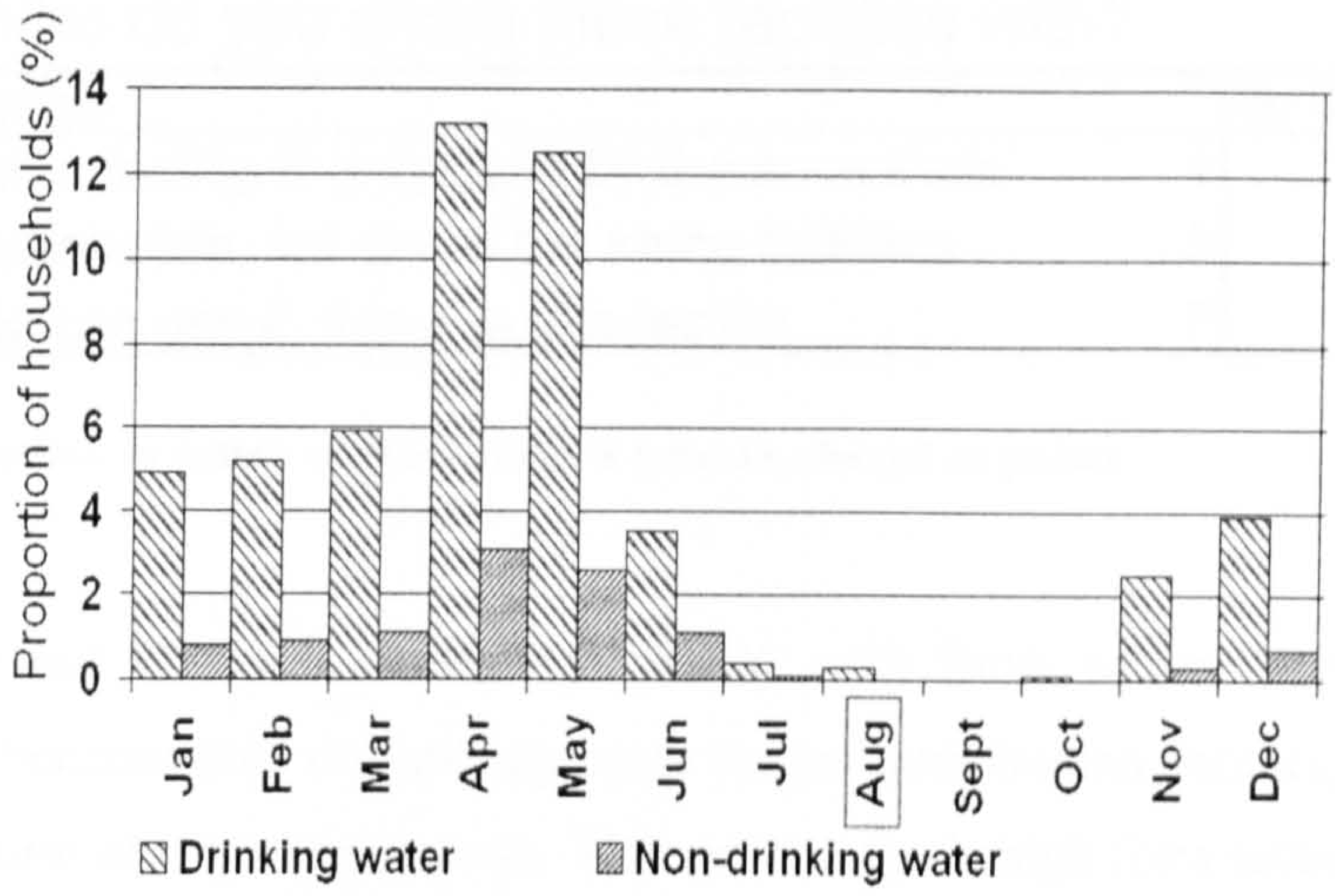
Table 8.18: Reasons for households not having access to water in Laos survey

The biggest difference for the water indicator between the Kenyan and the Laos survey is the way that intermittent supply was assessed. The Laos survey included two questions; the first asked if water was not collected/obtained in the last seven days. If this was the case, a follow-up question assessed the reasons for such interruption.

Reasons for interrupted supply:	(n=1002)
1. Could not pay for it;	1.5%
2. Had no time to collect it;	-
3. Not enough pressure/ no water available;	0.5%
4. Queues too long;	-
5. Health did not allow water collection;	-
6. Did not need any, had enough;	2.9%
7. Other (no details given).	0.1%

Table 8.19: Reasons for interrupted supply over the last seven days

Reasons one and three would result in the household not having access to water while six did not. The additional question thus addresses the problem identified in the Kenyan survey in which some situations were assumed (in error) to restrict access while in Laos the reasons for the reported restricted access were collected.



Graph 8.4: Seasonal variation in water sources in Thakhek, Laos

Graph 8.4 shows that, with regards to drinking water, the survey is representative for large parts of the year although towards the end of the dry season (April and May) more than 12% of the households interviewed used an alternative drinking water source while during the same period only 2-3% used an alternative non-drinking water source.

Reasons for non-access to sanitation	% of households affected (n=997)
Type of toilet unsatisfactory	55.4%
Public toilet	44.1%
Type of payment	0.3%
Unhygienic toilet	56.0%
Non-use of facility	51.4%

Table 8.20: Reasons for non-access to sanitation in Laos survey

Table 8.20 shows the reasons for which households would be classified as "not having access": the high number of public latrines based on the question in Figure 8.2; the prevalence of public latrines was found to be high until it was cross checked with the latrine type; and 98% of the people sharing the 'toilet' with people "they did not know" practised open defecation.

S32	Who do you share these facilities with?		
Coding categories		Go To	Remarks
Nobody, the facility is only used by the household	1		
Some households, we share the same facilities	3		
Everybody can use it, it is a public facility	7		

Figure 8.2: Question to assess whether toilet is private, shared or public

Almost one out of three households (29%) with flush toilets were considered unhygienic, because they did not segregate faeces from human contact, as described in the definition of improved access. This percentage is high for a technology which is generally considered hygienic. These cases were discussed with the surveyors to ensure that the visual inspection on which this data was based was accurate. Following long discussions the surveyors assured the author this was a correct assessment. A test assessing the three toilets in the office building where the team was based revealed that 89% of the surveyors agreed with each other (although two of those toilets were particularly unhygienic).

Unhygienic means that excreta or substances that appear to be excreta can be found on areas that can be touched during normal use of the toilet.

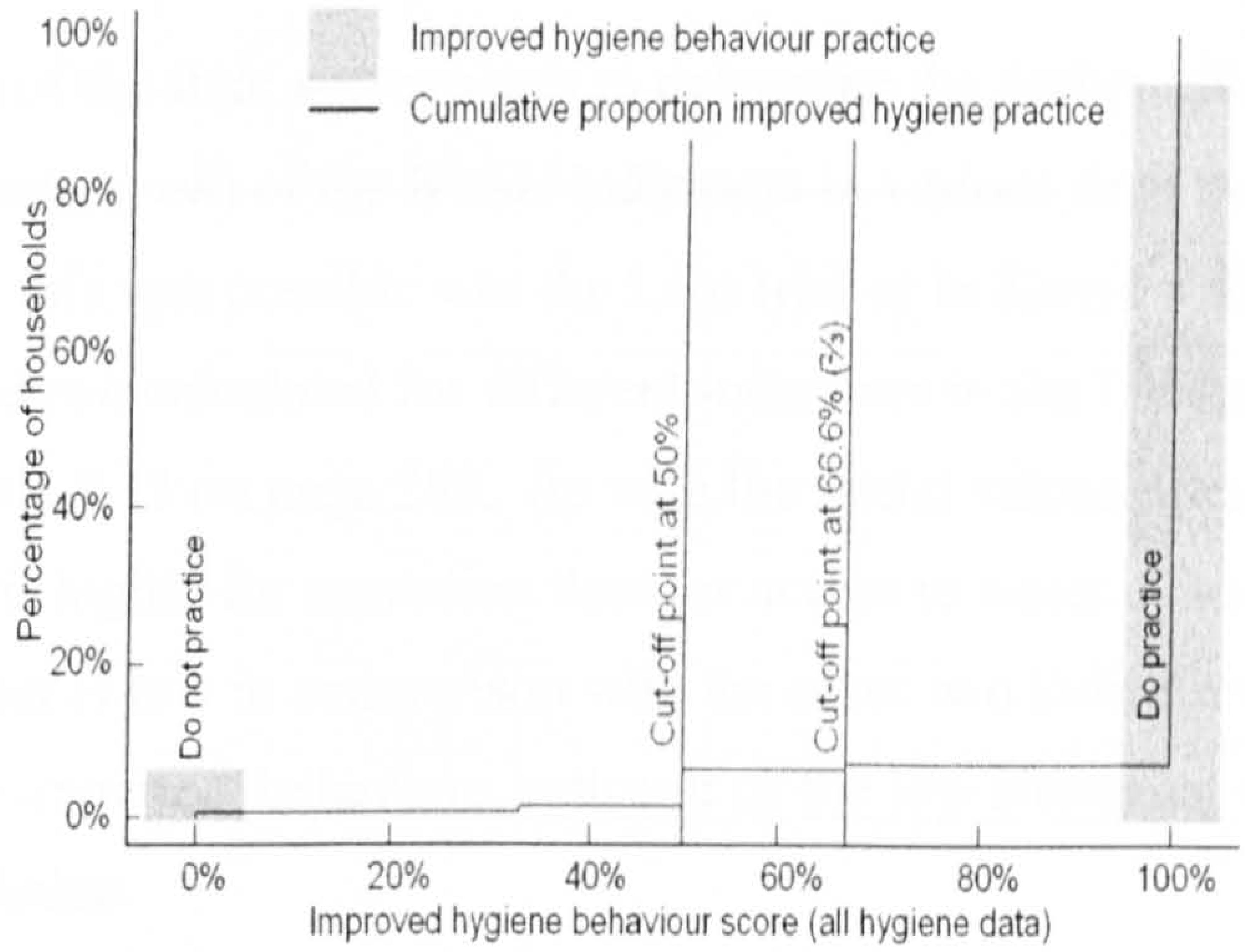
The last criterion in Table 8.20 assessed by observation the likelihood that the latrine was not in use. One in five (20%) of the households which used a suitable technology were, according to the surveyors, unlikely to be in use. In 70% of these cases it was because the latrine was outside the compound while in 13% the road to the toilet was not clear. Discussing these results, it became clear that in Laos many people own a toilet but few use it, preferring the bush instead. Ownership of a toilet is important, as recent national legislation classifies households who do not own a toilet as poor and those who can afford it build toilets so that they are not considered poor.

Initially the Laos survey contained a question about whether people practised open defecation away from home, when the toilet is occupied or during the night. The staff at URI insisted on asking how many days in the last seven days people practised open defecation (Table 8.21). While 97% of the households admitting to open defecation did not own a latrine; 2% had a flush latrine. Only one household of all those which did *not* practise open defecation away from the household practised it at home at night (four times in the last week). However 10% of the households not practising open defecation at home, stated that they had practised it over the last seven days when away from home.

# of days	0	1	2	3	4	5	6	7	Total
When away from the house	51.1	2.3	1.8	1.4	0.1	0.2	0	43.1	100%
When toilet is occupied	57.0	0.1	0.1	0.1	0	0	0	42.7	100%
At night	56.8	0	0.3	0	0.1	0.1	0	42.7	100%

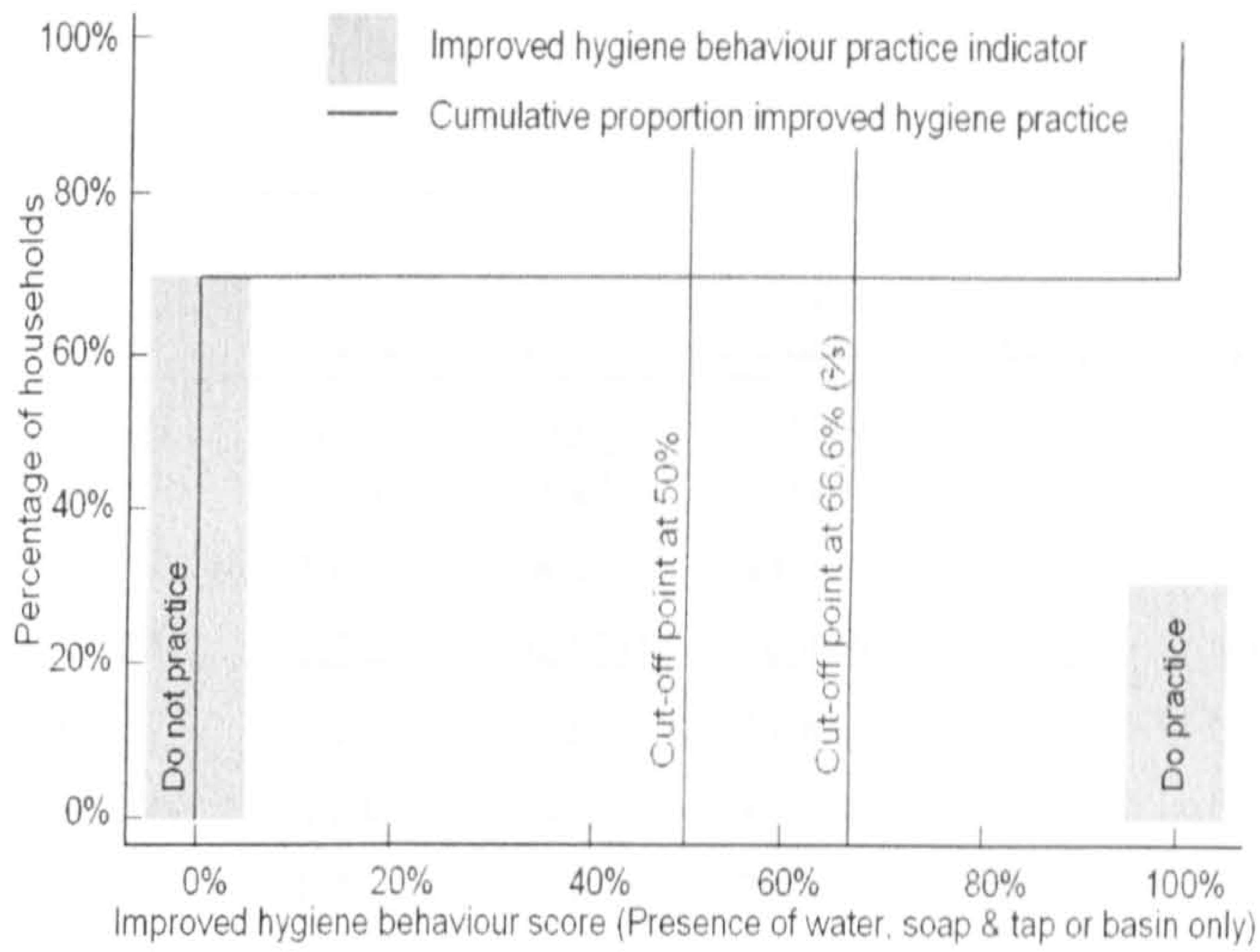
Table 8.21: Number of days open defecation was practiced over the last seven days

One of the major problems with the original hygiene indicator is that it uses a score built from three to five questions and observations relying on a subjective cut-off point to classify households according to their hygiene behaviour. The weight of each question is identical as there is no basis on which to weigh some of the questions more compared to other questions.



Graph 8.5: 'Improved' hygiene behaviour score using all hygiene data in Laos survey

Graph 8.5 shows two lines illustrating the cut-off points at 50% and at 67%. Including or excluding the cut-off value in either category can already make a difference in the reported prevalence of hygiene behaviour. Indicators not requiring cut-off points are significantly easier to analyse.



Graph 8.6: 'Improved' Hygiene behaviour spot observations of handwashing items

Such indicators could rely on a series of logical events such as the fulfilment of three criteria (presence of hand washing items) in Graph 8.6 which does not rely on any cut-off point.

8.3.3 Measuring of *deff* and *roh* in a sector specific survey.

One of the aims of the field surveys was to determine the design effects (*deff*) and the rate of homogeneity (*roh*) of the *WaSH* indicators in various field trials. The only survey in which this was possible was the Laos trial as in Kenya a SRS was used. The different *deff* and *roh* calculated for different indicators in the Laos survey are presented in Table 8.17 on page 289. As with the initial values calculated in Chapter 5 the clustering is higher for sanitation than for access to water. The clustering of hygiene behaviour is low in comparison with the other two indicators but it is unclear if this due to the imperfect behaviour indicator or the low clustering of behaviour within the population.

To assess whether such high clustering is common for WASH indicators, seven more data sets were analysed (Table 8.22)

Country	*Burkina Faso*	*Egypt*	*Ghana*	*Indonesia*	*Kenya*	*Morocco*	*Nigeria*
Indicator*	*Deff (roh)*	*Deff (roh)*	*Deff (roh)*	*Deff (roh)*	*Deff (roh)*	*Deff (roh)*	*Deff (roh)*
JMP water	19.0	1.0	8.0	11.7	9.1	10.5	12.87
	(0.828)	(0.0)	(0.478)	(0.469)	(0.55)	(0.413)	(6.25)
'*WaSH*' water	16.7	1.3	7.3	11.8	8.4	n/a	12.9
	(0.722)	(0.032)	(0.431)	(0.474)	(0.362)	(n/a)	(0.626)
JMP sanitation	22.4	1.2	4.1	21.4	6.4	4.5	13.7
	(0.984)	(0.034)	(0.212)	(0.896)	(0.264)	(0.152)	(0.668)
Collection time	7.2	1.7	4.7	7.6	7.3	n/a	7.9
(≥30min. Y/N)	(0.285)	(0.075)	(0.253)	(0.289)	(0.309)	(n/a)	(0.363)
WaSH hygiene	7.3	2.1	3.3	n/a	n/a	n/a	13.2
	(0.290)	(0.118)	(0.157)	(n/a)	(n/a)	(n/a)	(0.642)
Survey Information							
Year	2005	2003	2003	2004	2003	2004	2004
Sample size	9097	10089	6251	3088	8561	11513	7225
#PSU	400	980	412	1392	400	480	362
# Strata	2	488	203	679	188	232	177

WaSH indicators mentioned in this table approximate the indicators designed for this study with the data available in each data set. All data in the table are weighted and stratified

Table 8.22: *Deff* and *roh* for WASH indicators derived from 7 DHS data sets

The *WaSH* indicator used in Table 8.22 is an approximation of the indicator used in the field trials, based on the data available in each data set. For 'access to water' the *WaSH* indicator was a combination of source type and collection time, while for hygiene it was a combination of information available in each data set, which varied from data set to data set.

Although the values of *deff* and *roh* in Table 8.22 vary widely from survey to survey this table shows that the values obtained in Table 8.17 are not atypical, compared to the values obtained from existing DHS surveys.

8.3.4 Analysis of inter-interviewer variance.

In both the Kenyan and the Laos survey the allocation of households to the six different interviewers was partially random (within villages or areas) and partially by convenience (grouped by village or area). Assuming this attribution of households to each surveyor was completely random and each surveyor classifies access and practice in exactly the same way, the proportion of non-access households should be similar in each of the sub-samples interviewed by a particular surveyor. This subgroup would then contribute 16.7% of the households that have no access to the overall proportion of households not having access (Table 8.23 and Table 8.24).

Non-access to or non-practice of:	Contribution of each surveyor to the final result						
	A	B	C	D	E	F	Total
'Improved' Water*	9%	13%	27%	13%	21%	17%	100%
'Improved' Sanitation*	16%	8%	24%	17%	9%	26%	100%
Handwashing only*	20%	19%	19%	16%	20%	6%	100%
Proportion of interviews	19%	19%	13%	15%	17%	17%	100%

*All values are weighted for the number of interviews done by each survey pair

Table 8.23: Contribution of surveyors to the non-access or practice figures in the Kenyan survey

The table shows that that the proportion of households without access varies from surveyor to surveyor but also by indicator. One reason might be the high clustering of the indicators of interest, discussed above.

Non-access to or non-practice of:	Contribution of each surveyor to the final result						
	1	2	3	4	5	6	Total
'Improved' Water*	14%	18%	15%	17%	20%	16%	100%
'Improved' Sanitation*	11%	17%	19%	22%	18%	13%	100%
'Improved' Hygiene*	6%	29%	18%	19%	11%	17%	100%
Handwashing only*	9%	23%	12%	16%	21%	19%	100%
Proportion of interviews	17%	17%	16%	16%	17%	17%	100%

*All values are weighted for the number of interviews done by each surveyor

Table 8.24: Contribution of surveyors to the non-access or practice figures in the Laos survey

The clustering of the measure of interest, together with keeping surveyor groups in the same area for convenience, might be one of the reasons for the differences in the tables. By making a model through logistical regression and taking into account the clustering as a categorical explanatory variable this estimate can be compared to the estimates of a model that includes the villages as well as the surveyors. Comparing the maximum likelihood ratio from the two models allows one to assess how similar they are. If similarity is high it can be concluded that there is little variation between the surveyors while adjusting for the variation between clusters. If the *p*-values of the maximum likelihood test are low this can be because of surveyor bias or clustering of information beyond the village not being taken into account in the model.

This approach is only possible with the data from the Laos survey as the Kenyan data set was based on a SRS and did not contain any information on geographical clustering.

WaSH indicator	*p*-value likelihood ratio test
'Improved' Water	0.0875
'Improved' Sanitation	0.0000
'Improved' Hygiene	0.0000
Handwashing only	0.0000

Table 8.25: *p* values for the logistic regression values including and excluding surveyors.

In Table 8.25 two models of each indicator are compared for each indicator. A model based on a logistical regression with the *WaSH* indicator as outcome and the village and observer as explanatory variables, is compared with a similar model that uses only the village as an explanatory variable. The table shows that while for the water there are some resemblances in both models, introducing the surveyors in the other models changes the model in such a way that that they are unlikely to be the same. This might indicate that there was a high variation in the way surveyors collect information for the three last indicators in Table 8.25. One of the reasons could be is that the observations, included in all but the water indicator, are more difficult to standardise between surveyors, allowing possible surveyor bias.

8.3.5 Financial analysis

In Chapter 5 an estimated cost ratio of 450 between the fixed cost of one BSU and the fixed cost of one cluster, was used to optimize the sample design. This section determines the real cluster sample cost ratios in the Kenyan and Laos survey. Although there are also differences in the empirical *roh* from the value of 0.31 used in Chapter 5, this value is kept constant here to facilitate comparisons.

Cluster-sample cost ratio in Kenyan trial

Although the survey did not follow the planned cluster design the survey area and costs would have been identical. Cluster costs are mainly transport cost and the time surveyors spend in transport between clusters even though it is difficult to estimate how much time is actually spent. In the Kenyan survey, the different PSU would be alongside one another and would not have required extra transport by vehicle.

Cost type	Cost in £ Sterling[1]	%.	Remark
Fixed	£ 5629	39	Independent of survey design
Validation	£ 1847	13	Attributable to validation of research
Training	£ 625	4	For training of survey field staff
Cluster	£ 3699	26	Cost related to the 32[2] clusters
Sample	£ 2463	17	Cost related to the 727[2] samples
TOTAL	£14264	100	

Table 8.26: Listing of costs in Kenyan trial.

For the sample size of the survey in Equation 8.3 below the actual sample size of 727 was chosen over the planned size of 1024 as obtaining the latter sample size would have led to higher survey costs.

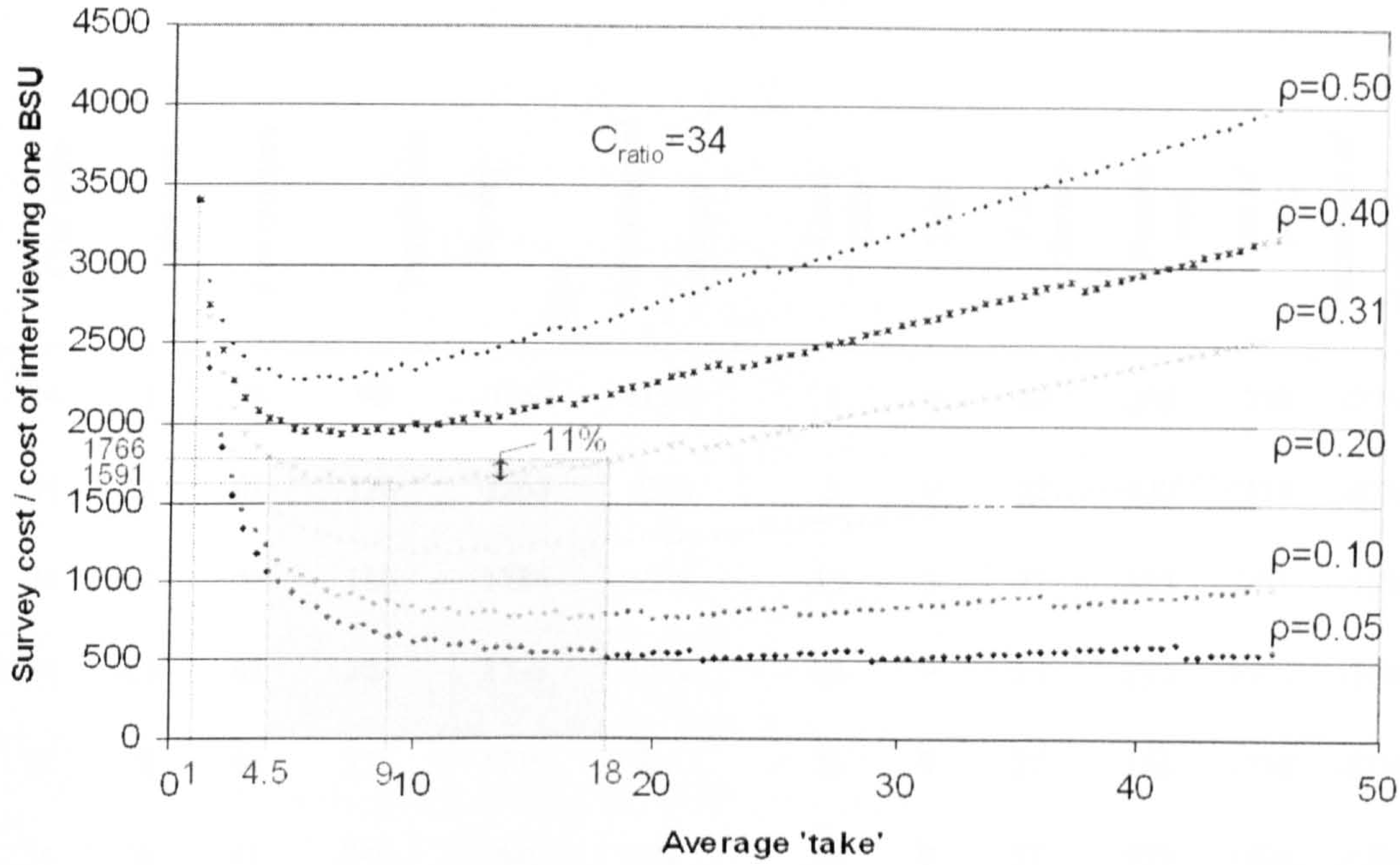
$$\text{Cluster - sample cost ratio} = \frac{\text{Cost\_clusters}/\#\text{ of clusters}}{\text{Cost\_samples}/\#\text{ of samples}} = \frac{£\,3699/32}{£\,2463/727} = 34$$

Equation 8.3: Cluster-sample cost ratio in Kenyan survey

This means that the 'fixed costs for a cluster equals 37 times the cost of an individual sample. This is much lower than the 450 estimated in Chapter 5.

1 Survey field cost as reported by Netwas Kenya.

2 Planned number of clusters and actual number of samples as sample designed was changed.



Graph 8.7: Take size at minimum survey cost for a cost ratio of 34

Using the cost ratio of 34 and an equal rate of homogeneity of 0.31, precision of 10% and reliability coefficient of 1.96 (95% reliability) would give sample sizes as shown in Table 8.27. According to Equation 5.19 the ideal take size is calculated as:.

$$\bar{b} = \sqrt{\frac{C_{ratio}(1-\rho)}{\rho}} = \sqrt{\frac{34(1-0.31)}{0.31}} \cong 9$$

Equation 8.4: Calculation of take size for a cost ratio of 34

Using a take of nine in Equation 5.11 gives the required number of clusters needed for a cost ratio of 34.

$$c = \frac{96(1-\rho)+96.\rho.\bar{b}}{\bar{b}} = \frac{96(1-0.31)+96\cdot 0.31\cdot 9}{9} \cong 37$$

Equation 8.5: Calculation of the required number of cluster for a cost ratio of 34

Graph 8.7 and Table 8.27 show the same take size of nine for a survey at minimal cost as well as a highlighted region in which the cost is within 11% of the optimal cost.

Cost ratio	Take size	# of clusters	Sample size	Survey Cost	Percentage of optimum
34	1	96	96	3360	111%
34	2	63	126	2268	43%
34	4	47	188	1786	12%
34	4.5*	45	203	1733	11%
34	5	44	220	1716	8%
34	6	41	246	1640	3%
34	8	39	312	1638	3%
34	**9**	**37**	**333**	**1591**	**0%**
34	10	37	370	1628	2%
34	12	36	432	1656	6%
34	14	35	490	1680	6%
34	16	35	560	1750	10%
34	18	34	612	1768	11%
34	20	34	646	1802	13%

* Average take to obtain ±10% cost limit

Table 8.27: Sample size for a cost ratio of 34

Cost ratio	Take	# of clusters	Sample size	cost of BSU	Percentage of optimum
1	9	37	333	370	-77%
5	9	37	333	518	-67%
10	9	37	333	703	-56%
20	9	37	333	1073	-33%
25	9	37	333	1258	-21%
29	9	37	333	1406	-12%
30	9	37	333	1443	-9%
34	**9**	**37**	**333**	**1591**	**0%**
34	9	37	333	1591	0%
35	9	37	333	1628	2%
38	9	37	333	1739	9%
39	9	37	333	1776	12%
45	9	37	333	1998	26%
50	9	37	333	2183	37%

Table 8.28: Cost ratios using 9x37 sample

In Table 8.27 the cost ratio is kept constant while the survey cost is determined for of the cluster and take sizes, which result in the same precision of the estimate. Table 8.28 it is the opposite, the 'new' optimal cluster-take size of Table 8.27 is kept constant while the cost is calculated for different cost ratio.

The highlighted region in the table shows the area in which the cost variations are within 9% of the optimum calculated in Table 8.27. For all values in both tables *roh* and precision are kept constant.

Cluster-sample cost ratio in Laos

As with the Kenyan survey the costs of the survey are grouped in five different categories (Table 8.29). Category one are fixed costs relating to the planning of a survey such as international phone calls, e-mail exchanges, and permits and salaries for people doing preparative work. Category two are costs relating to the validation work, which amounts to more than all the other categories together. These include the cost of additional staff doing structured observation, transport cost of validation staff and other costs that would not be part of a normal survey. Category three costs are related to training and can be considered as fixed costs because they do not change significantly when the number of participants increases or decreases.

The cost attributed to clusters in category four are mainly transport costs and costs for rental of vehicles, while the sample costs in category five are mainly the costs of reproducing the paper survey forms, salaries of interviewers and the cost of data entry.

	Cost type	Cost in £ Sterling[1]	%	Remark
1	Fixed	£ 478	2	Independent of survey design
2	Validation	£ 13406	61	Attributable to validation of research
3	Training	£ 3074	14	For training of survey field staff
4	Cluster	£ 2048	9	Cost related to the 32 clusters
5	Sample	£ 3016	14	Cost related to the 1056 samples
	TOTAL	£22022	100	

Table 8.29: Grouping the survey cost in Pounds Sterling for the Laos survey

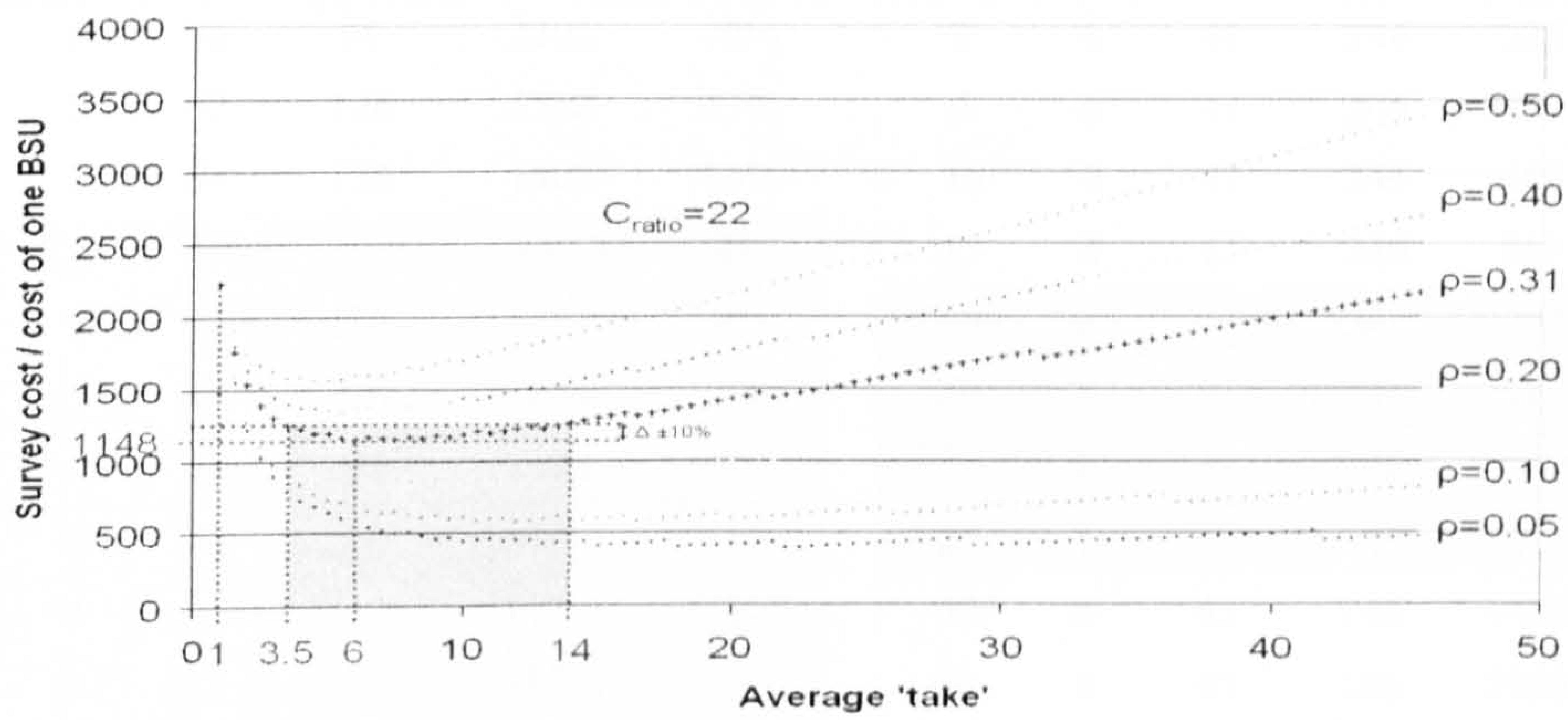
The cost ratio introduced in Chapter 5 paragraph 5.4.4 can be calculated with the figures from Table 8.29 as shown in Equation 8.6.

[1] Survey field cost as reported by URI the implementing organization in Laos.

$$\text{Cluster, Sample cost ratio} = \frac{\text{Cost\_clusters}/\#\text{ of clusters}}{\text{Cost\_samples}/\#\text{ of samples}} = \frac{£\,2048/32}{£\,3016/1056} = 22$$

Equation 8.6: Cost ratio calculation for the Laos survey

The sample size used in Equation 8.6 is the 1056 targeted, because costs were incurred in the trial to obtain this sample size. The fixed costs for a cluster are equivalent to the cost of 22 individual samples according to Equation 8.6. As in the Kenyan survey this is much lower than 450 estimated in Chapter 5 and would have resulted in a different optimum of number of clusters and take sizes as illustrated in Graph 8.8.



Graph 8.8: Optimum take size for a cost ratio of 22

Using the cost ratio of 22 and an equal rate of homogeneity of 0.31, precision of 10% and reliability coefficient of 1.96 (95% reliability) would give sample sizes as shown in Table 8.30. According to equation 5.19 the ideal take size is:.

$$\bar{b} = \sqrt{\frac{C_{ratio}(1-\rho)}{\rho}} = \sqrt{\frac{22(1-0.31)}{0.31}} = 6.997695 \cong 7$$

Equation 8.7: Calculation of take size for a cost ratio of 22

Using a take of 7 in Equation 4.11 gives the required number of clusters needed for a cost ratio of 22.

$$c = \frac{96(1-\rho)+96.\rho.\bar{b}}{\bar{b}} = \frac{96(1-0.31)+96\cdot 0.31\cdot 7}{7} = 39.22597 \Rightarrow 40$$

Equation 8.8: Calculation of the required number of cluster for a cost ratio of 22

The above determines that 40 clusters are required. However, due to the rounding up required as take sizes and cluster number have to be whole numbers, Table 8.30 shows a combination that is around 1% cheaper.

Cost ratio	*Take* Size	# of Clusters	Sample size	Survey cost	Percentage of 'new' optimum
22	1	96	96	2208	92%
22	2	63	126	1512	32%
22	3	52	156	1300	13%
22	3.5*	49	171.5	1249.5	9%
22	4	47	188	1222	6%
22	5	44	220	1188	3%
22	**6**	**41**	**246**	**1148**	**0%**
22	7	40	280	1160	1%
22	8	39	312	1170	2%
22	9	38	342	1178	3%
22	10	37	370	1184	3%
22	11	36	396	1188	3%
22	12	36	432	1224	7%
22	13	35	455	1225	7%
22	14	35	490	1260	10%
22	15	35	525	1295	13%

* Average take added to obtain ±10% cost limit

Table 8.30: Sample size for a cost ratio of 22

Cost Ratio	Take	# of Clusters	Sample size	cost of BSU	Percentage of 'new' optimum
1	6	41	246	287	-75%
5	6	41	246	451	-61%
10	6	41	246	656	-43%
15	6	41	246	861	-25%
19	6	41	246	1025	-11%
20	6	41	246	1066	-7%
22	**6**	**41**	**246**	**1148**	**0%**
25	6	41	246	1271	11%
30	6	41	246	1476	29%
40	6	41	246	1886	64%
45	6	41	246	2091	82%
50	6	41	246	2296	100%
55	6	41	246	2501	118%
60	6	41	246	2706	136%
65	6	41	246	2911	154%
70	6	41	246	3116	171%
75	6	41	246	3321	189%

Table 8.31: Cost ratios using 6x41 sample

In Table 8.30 the cost ratio is constant and the cluster and take sizes vary while in Table 8.31 it is the opposite, the 'new' optimal cluster take size of Table 8.30 while the cost is calculated for different cost ratio. For all values in both tables, *roh* and the precision of the estimate are kept constant.

Using six as the *take* instead of seven, as shown below, requires rounding up closer to the obtained decimal figure.

$$c = \frac{96(1-\rho)+96.\rho.\bar{b}}{\bar{b}} = \frac{96(1-0.31)+96\cdot 0.31\cdot 6}{6} = 40.8 \cong 41$$

Equation 8.9: Calculation of the required number of cluster for a cost ratio of 22 and *take* 6

A survey with a take of 6 and 41 clusters would reduce the survey cost as shown in Table 8.30. Table 8.31 shows that each percentage increase in the cost ratio increases the survey cost by the same percentage once the take size and number of clusters are chosen.

As a result of the relationship this reveals about the survey costs, it will be important to study the survey cost ratio in more detail, particularly when the cost ratios are low.

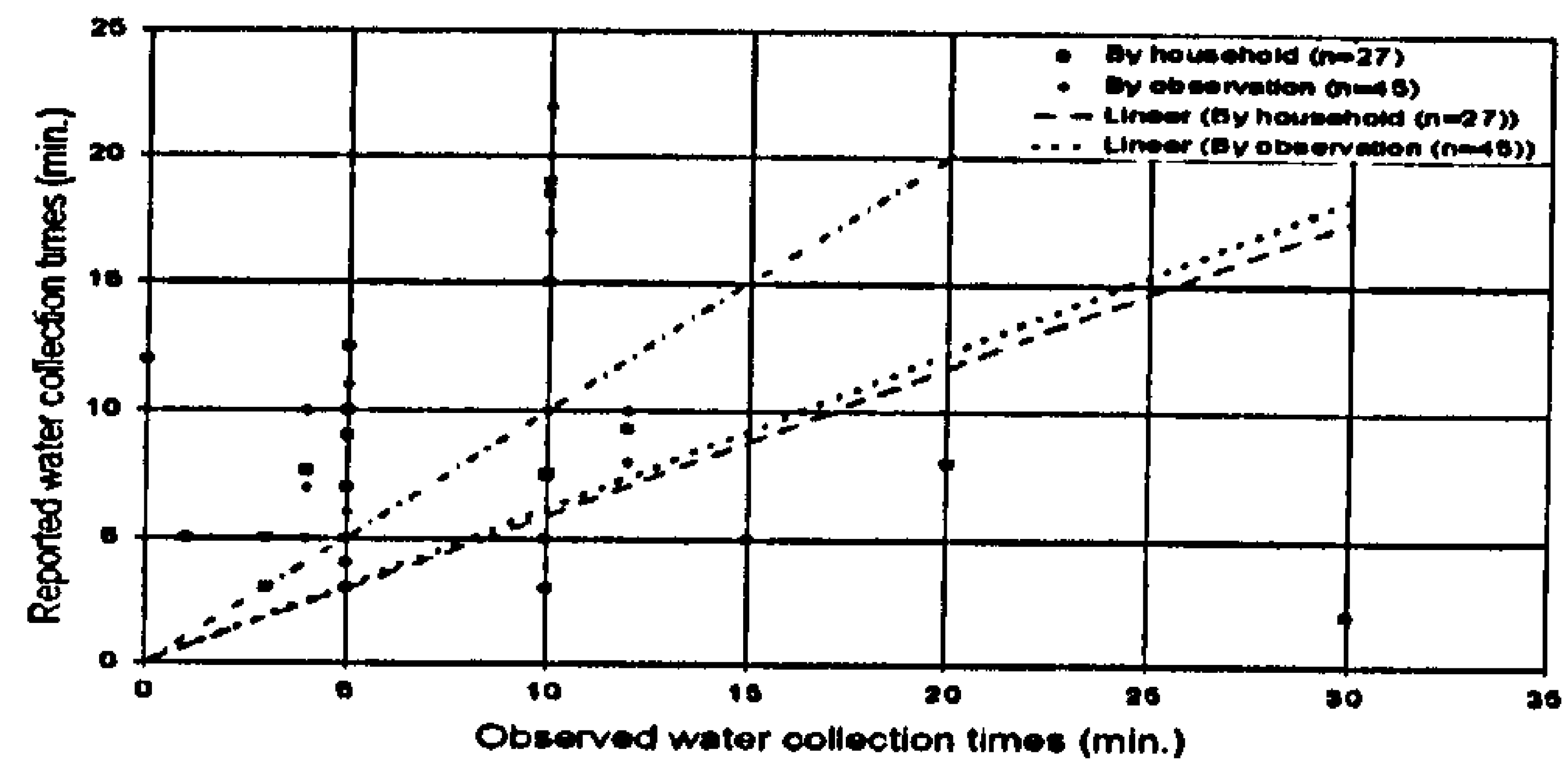
8.4 Validation

In Kenya and Laos there were three instances in which household data collection was validated. The first one was the main survey which included an interviewer-administered **questionnaire, spot observation** and **pocket voting** at the household level. The second is **structured observations** of a randomly selected sub-sample of around 10% of the interviewed households. A mix of **focus group discussions** and **focus group interviews** was used as a third way of data validation.

8.4.1 Kenyan validation

Journey time for collecting water

Only 32 interviews could be matched with certainty with an observation. From those, 27 households collected water while being observed, resulting in 45 measurements of water collection journey times. Graph 8.9 compares the collected and observed water collection journey times. "*By observation*" in the graph compares each observed collection time with the reported time, while "*by household*" compares the average collection time per household with the reported time. From the graph it is clear that for both data series "*By household*" and "*By observation*" most of the points are above the red dashed diagonal line in Graph 8.9 which means that most of the reported times were most of the time higher than the measured times.



Graph 8.9: Scatter plot of observed versus reported water collecting journey times

A compilation of these findings can be found in Table 8.32.

One of the observations was excluded from the data as the trip did not result in obtaining water so it was difficult to attribute a time to that observation. The following trip, more than two hours later, was successful and was included in the sample.

Reported times (t_r) compared to measured times (t_m)				Average Δt reported (%of t_m)	
Analysis by	$t_r < t_m$	$t_r = t_m$	$t_r > t_m$	Under	Over
Observations (n=45)	21 (47%)	10 (22%)	14 (31%)	-53%	+95%
Households (n=27)	11 (41%)	7 (26%)	9 (33%)	-35%	+90%

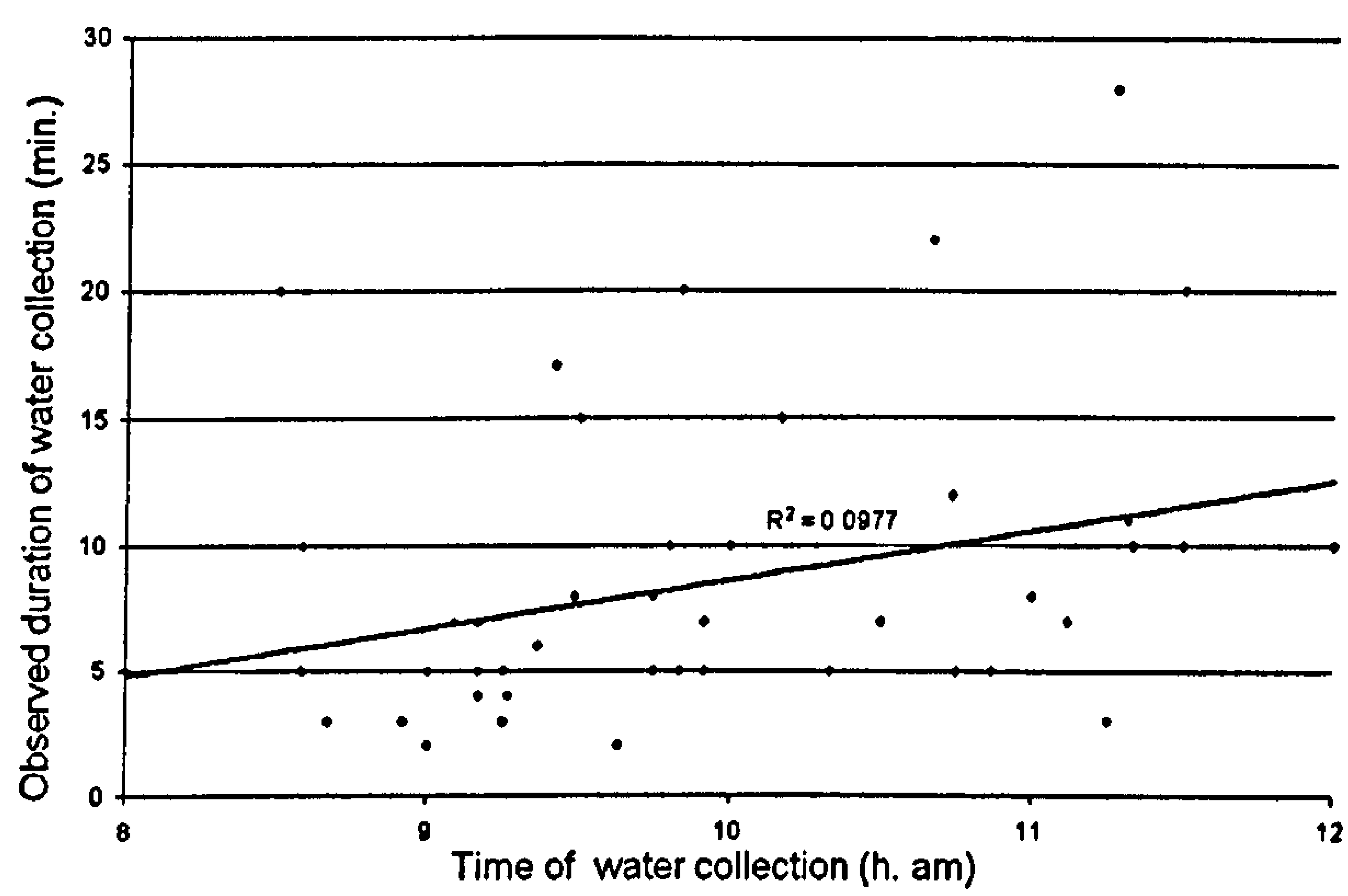
Table 8.32: Under and over reporting of water collection times in Kenyan survey

In the table only one third of the households over-reported their collection times. Over-reporting is larger than under-reporting as can be seen from the last two columns in Table 8.32. However the average reported time is 7.7(±2.3)min. while the observed was 8.2(±1.5)min. The null hypothesis that both reported and observed data come from the same group could not be rejected, with a p-value of 0.13. The range of the household reported data was 0-30 min. while the observed was 3-22 min. As the collection times were all below the 30 min. cut-off point regarding access, none of the households had to be reclassified because of discrepancies between reported and measured water collection times.

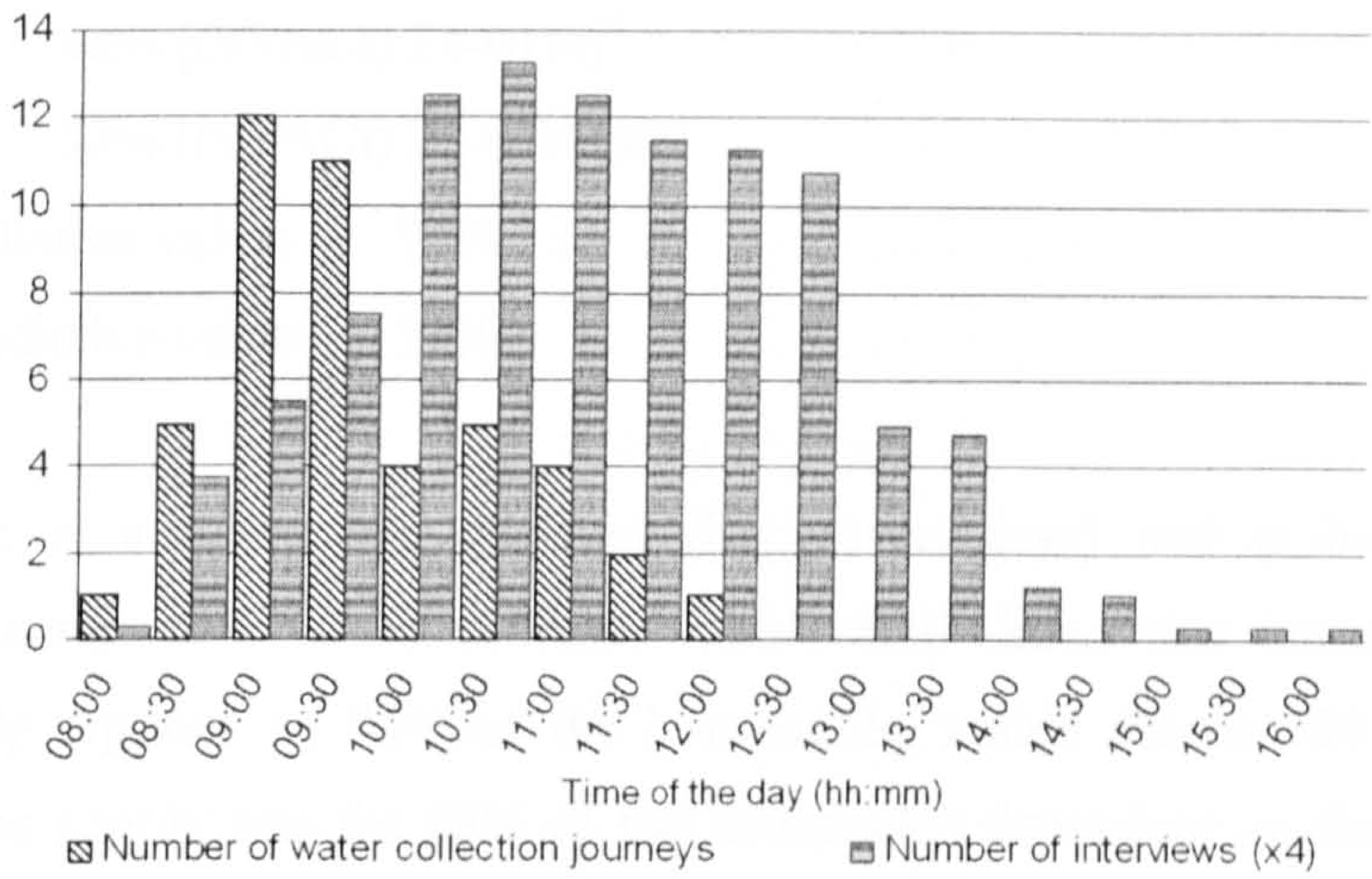
The limited time spent in the household during the observation makes it difficult to assess people spending more than half a day to collect water. During the focus group discussions it was clear that some households waited to collect water until the observer left the house as they did not want to leave the house alone with the observer. This could also mean that households, given a choice of water sources, may choose a closer source when observed, in order not to leave the house for too long and therefore changing their behaviour.

Households who did multiple trips had various times for different water collection trips, indicating that collection times might vary over the day or when different sources were used for water collection.

Graph 8.10 shows the observed duration of the water collection journey versus the time at which the journey stated. There is no clear pattern emerging in collection times during the day. The collection time in Graph 8.11 covers the times the observations were planned for (8 am to 1 pm). From the graphs it is clear that most water is collected early morning, most likely in preparation for an early lunch which is the main and often the only meal eaten in the Kenyan settlement.



Graph 8.10: Observed duration versus time of the day for water collection in Korogocho, Kenya



Graph 8.11: Time of the day for water collection and interviews in Korogocho, Kenya

Type of source

The type of source registered by the interviewer was in 86% (n=28) of the cases the same as that seem to be used. However, in no case did it change the access indicator as 98% of the households rely on acceptable (piped) water sources (Table 8.10). The discrepant cases are four households which, according to the survey had 'piped water in dwelling' (code 11), and according to the validation should have been (code 12) 'piped water in yard/plot'.

Water access indicator

Table 8.33 shows the cross table comparing access figures for water obtained by data collected in the survey and data obtained through observation. One of the main reasons for the discrepancy between the *WaSH* indicators and the validation data in Table 8.33 is that the most important criterion for non-access, intermittent supply in the last seven days (Table 8.10), could not be observed for validation.

Water Indicator		Observed access (validation)		
WaSH indictor excl. payment)	(n=31)	access	non-access	Total
	access	32 % (10)	10 % (3)	42 %
	non-access	45 % (14)	13 % (4)	58 %
	total	77 %	23 %	100 %

Table 8.33: Validation water indicator in Kenyan field trial

Sensitivity: 42% [(95%CI) 24-61%][1]

Specificity: 57% [(95%CI) 25-84%]309

Positive predictive value: 77%

Negative predictive value 22%

Intermittence is a retroactive question (last seven days) and is because of its intermittent nature difficult to validate. Table 8.10 shows that intermittence was independently reported in 95% of the households, which means 384 independent cases. As the supply was for 98% of the households dependent on the same piped distribution network it can be safely assumed that in the majority of cases intermittence was accurately reported, which is a form of validation of this indicator. It would be helpful in the validation to determine why the 3% who did also depend on the piped water did not report intermittent water supply.

Sanitation access

	Sanitation indicator	Observed access (validation)		
WaSH indictor	n=16	access	non-access	total
	access	13%	6%	19%
sanitation	non-access	50%	31%	81%
	total	63%	37%	100 %

Table 8.34: Validation of the sanitation indicator in the Kenyan survey

Sensitivity: 20% [(95%CI) 7-50%]

Specificity: 83% [(95%CI) 36-96%]

Positive predictive value: 66%

Negative predictive value 38%

[1] Confidence intervals on sensitivity and specificity of all data in this chapter have been calculated with the Wilson score method without continuity correction

The discrepancy highlighted within the validation of sanitation is probably due to the public and shared latrines which were hardly present in the validation data. Only five out of 16 observations mention public latrines, in contrast with the survey data which identified more than two-thirds of the toilets used as public. When analysing the survey data of those observation which had missing data for sanitation, it confirms that most respondents depend on public latrines. However, it cannot explain how half of the households are classified by the observation as having access while the survey classifies them as not having access. These discrepancies were only noticed after leaving Kenya, when it became difficult to discuss with the observers what their cause. The limited number of paired records for the validation of the sanitation indicator limits the usefulness of Table 8.34.

Hygiene behaviour

Only nine out of 32 observed households had at least three hygiene observations, of which only two had two-thirds 'improved' behaviours. With such a low prevalence the predictive values have limited worth and for that reason are omitted for hygiene behaviour.

Hygiene indicator		Observed behaviour		
	n=9	'improved'	non-improved	total
WaSH indictor (Handwash items)	'improved'	11%	33%	44%
	non-improved	0%	56%	56%
	total	11%	89%	100 %

Table 8.35: Validation of the hygiene indicator in the Kenyan survey

Sensitivity: 100% [(95%CI) 20-100%]

Specificity: 63% [(95%CI) 31- 86%]

8.4.2 Laos validation

In the Laos survey, more attention was given to the pairing of observations and interviews, resulting in 101 paired data records. Initially it was planned to have half of the observations before and the other half after the interview. This would allow assessment of how the data collection methods might influence each other. Due to the distances between the clusters and logistical constraints in moving observers around the survey area, this plan had to be abandoned as not enough observations could be made before each cluster was interviewed.

Water

Validating the water indicator during the Laos survey proved more difficult than in Kenya. While 47% of the observed households reported that bottled water is delivered to their home, only two households received such deliveries during the observation. In 14% of cases, piped water delivered in the house while 31% had a well beside the house, which was often equipped with an electric pump to deliver water inside the dwelling. This makes water collection a brief event and not always easy to observe. Although 58% of the observations noted information on the physical water collection, only 47% mentioned the type water source.

In 83% of cases, the water sources matched between the interview and the observation. That percentage is high considering that 61% of the households used multiple sources and it was not always easy to determine by observation which was the source for drinking water. There was also confusion over the classification "piped in the house" when that water came from a private well instead of a local distribution network, particularly if that well was unprotected. Without that confusion, over 90% concordant pairs could be obtained.

Water collection times		2nd water source		
	n=389	<=30 min.	>30 min.	total
1st water source	<=30 min.	99 %	1 %	100 %
	>30 min.	0 %	0 %	0 %
	total	99 %	1 %	100 %

Table 8.36: Validation of the water collection time in the Laos survey

Overall, 90% of the households surveyed take less than 30 min. to collect their drinking water.

For almost 99% of households that use multiple sources, both the drinking water source and the source used for hygiene are within a 30 min. reported collection time.

73% of those using multiple sources use bottled water as their primary drinking water source and 10 % use an unprotected public well as their primary source.

More importantly, all households who used bottled water as a drinking water source reported an alternative source of water for hygiene purposes.

Reported times (t_r) compared to measured times (t_m)
(drinking and non-drinking water)

Analysis by	$t_r < t_m$	$t_r = t_m$	$t_r > t_m$	Average Δt reported Under	Over
Observations (n=72)	54 (75%)	16 (22%)	2 (3%)	-43%	+72%
Households (n=57)	40 (70%)	15 (26%)	2 (4%)	-34%	+70%

Table 8.37: Under and over reporting of water collection times in Laos survey

Table 8.37 shows that from the 101 observed surveys only 57 collected water or received delivered water during observations. As in the Kenyan survey the collection times were over-estimated during the interview compared with the observed values. Some observations had to be disregarded for the validation as it was not clear if the observed collection time regarded drinking or non-drinking water.

Sanitation

Less that 20 sets of validation observations were made regarding sanitation in 16 observed households. The recording of these observations were vague. It is not clear if this was due to the reluctance of the observer to observe and record such behaviours or due to the discretion with which such activities were done while being observed. Unfortunately the notes on the observations on sanitation did not allow validation of the sanitation indicator in the Laos survey.

Hygiene

After unsatisfactory results for the initial hygiene behaviour indicator in the Kenyan survey, different indicators were tested in the Laos survey. For hygiene, the first indicator used was the same as that designed in Chapter 4 and used for field testing in the Kenyan survey. It uses scores on a minimum of three 'answered' questions in which at least two had to be 'improved' for the whole household to be classified as a household practising 'improved' hygiene behaviour.

Hygiene behaviour		Observed behaviour		
	n=97	'improved'	non-improved	total
All survey info	'improved'	2 %	32 %	34 %
	non-improved	0 %	66 %	66 %
	total	2 %	98 %	100.0 %

Table 8.38: Validation of original Hygiene behaviour indicator based on scoring in Laos survey

Sensitivity: 100% [(95%CI) 35-100%]

Specificity: 67% [(95%CI) 58-76%]

Positive predictive value: 6% (Prevalence of 2%!)

Negative predictive value 100% (Prevalence of 2%!)

For a true prevalence of only 2% predictive values are not useful and will not be calculated for the other hygiene indicators.

The second indicator used pocket voting to assess hand washing at critical times. The score calculated the number of critical handwashing moments multiplied by the number of persons for which handwashing was reported, divided by the total number of critical handwashing moments and the number of persons participating in the pocket voting. If in at least two-thirds of the critical moments, hand washing was reported by the household, they were considered as having 'improved' hygiene behaviour (Table 8.36).

Hygiene behaviour		Observed behaviour		
	n=99	'improved'	non-improved	total
Pocket voting*	'improved'	2 %	91 %	93 %
	non-improved	0 %	7 %	7 %
	total	2 %	98 %	100.0 %

* Cut-off point was 2/3 of reported handwashing after handling faeces or before handling food

Table 8.39: Validation of the hygiene indicator (pocket voting) in the Laos survey

Sensitivity: 100% [(95%CI) 34-100%]

Specificity: 7% [(95%CI) 4- 14%]

The third hygiene indicator assessed was the use of spot observations to assess whether items such as water, soap (or other cleansing agent) and a tap, sink or bowl were available (Table 8.40).

Hygiene behaviour		Observed behaviour		
	n=97	'improved'	non-improved	total
Spot observations	'improved'	2 %	35 %	37 %
	non-improved	0 %	63 %	63 %
	total	2 %	98 %	100.0 %

Table 8.40: Validation of hygiene behaviour indictor in the Laos survey

Sensitivity: 100% [(95%CI) 34-100%]

Specificity: 64% [(95%CI) 54-73%]

The validation of the indicator will be discussed in Chapter 9

8.5 Testing the sample frame

To test the accuracy of the sample frame, capture-recapture techniques were considered in the Kenya trial. These are widely used in biology to estimate population sizes. Information on how many compounds were listed in the sample (capture) but could not be found on the ground is listed in Table 8.3. The recapture requires information about a number of randomly-selected compounds on the ground, and checking how many are represented in the listing which forms the sample frame. However, time constraints and problems with clear identifiers for households did not allow this. There are other indications that sampling as done in the survey was rigorous.

During the group discussion among a sub-sample of the people interviewed, most of the people stated that this was the first time they had ever been interviewed. The only woman who mentioned being interviewed many times before said " *...it was the first time some feedback had been given*" on the survey. The person often interviewed mentioned that Korogocho is a place in which many surveys are done and many people suffer from interview fatigue. As mentioned by the same person "*... people were tired of being interviewed and nothing came out of it*". Many surveys are held in Korogocho and other informal settlements but few of these seem concerned with or aware of issues concerning representative sampling. The fact that most of the randomly selected people in the focus group discussion had never been interviewed seems to indicate that, despite the problems in achieving representative sampling, the sample seems to be more representative than most other surveys held in Korogocho. What is unknown about the participants in the focus group is how long they had lived in Korogocho; but the focus group facilitator considered it unlikely that all of the participants arrived recently. On the contrary, from the way they participated in the discussions it was clear that most of them had lived in Korogocho for years.

8.6 Practical implementation

During the surveys all survey staff were interviewed and discussion took place with interviewers and observers involved in the data collection regarding their perceptions on the surveys held. This last section presents some of the results of these assessments. In Kenya, finding the right compound during the survey proved challenging and some field staff did not always go to the assigned household. Sometimes they just selected a household. There were even claims that survey data were made up without visits. In the analysis of the methodology with the surveyors and observers, some pocket voting was used to assess the extent of such practices (Table 8.41).

Did you ever fill in information (invented data) that was not collected through interview or observation?

ANSWER:	(n=24, pocket votes)	proportion (%)
Never		92%
Sometimes		8%
Regularly		0%
Always		0%
	Total:	100%

Table 8.41: Results of pocket votes assessing the extent of invented data in Kenyan survey

Through group discussions it was not clear if 'sometimes' regarded a question on a form or the whole form. Selecting households which were not included on the sample list was reported by one observer (Table 8.42). To ensure that observation and survey were taking place in the same household, these households were identified together by the observer and the surveyor the day before.

Did you ever choose a household that was not on the list to collect data, without informing us?

ANSWER:	(n=24, pocket votes)	proportion (%)
Never		96%
Sometimes		4%
Regularly		0%
Always		0%
	Total:	100%

Table 8.42: Reported rigour in selecting households on the sample list in the Kenyan survey

In Laos similar assessments were made (Table 8.43) but there was no distinction in the voting between observers and interviewers because there were only six interviewers. It showed that a large number of survey staff admitted to making up information, but the amount of made-up information was difficult to assess. In group discussions, it became clear that the more difficult or embarrassing it becomes for the survey staff to collect data, the more likely they will fill in what they consider to be the answer rather than what they observed, or answer on the question they should have asked. It was difficult to discuss this issues extensively because of language and cultural barriers.

Did you ever fill in information (invented information) that was not collected through interview or observation?

ANSWER: (n=15, pocket votes)		%
I fully made up information		0%
I often made up some of the information		27%
I sometimes 'corrected' some forms with uncollected data		7%
I never made up any information		67%
	Total:	100%

Table 8.43: Surveyor's Evaluation Questionnaire Laos survey

The next chapter will discuss the results of the analysis in this chapter and assess how these relate to the overall goal of the study, while the last chapter will draw conclusions and make recommendations regarding the development of a WASH survey methodology.

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simplified that it resulted in a dressed-up convenience sample. The 'random' walk walk described proved to be far from random. Chapter 5 demonstrated that even established methods such as the EPI-sampling were used correctly, they would not be suitable to measure water and sanitation access indicators. One of the reasons is a higher clustering of access to water and sanitation indicators compared to the vaccination indicator for which EPI-sample methods were designed . In Laos, the collaborating institution was aware of basic statistical analysis but had little knowledge of how to collect the data so as to be suitable for such analysis and inference.

9.2.1 Household as BSU and its representation

The basic sampling unit used in the *WaSH* survey trials was the household. This was based on the assumption that access and behaviour at the household would be similar for each person in the same household.

Analysis in Chapter 8 showed that there was no significant difference in results when the respondent in the *WaSH* interview was a man, a woman or a child. This does not mean that there are no differences, but just that these differences were not statistically significant enough to be measured given the available sample. It would still be prudent to aim questions regarding water supply to women who are in most cases involved in its collection.

For the water indicator, it is likely that all the members of the household use the same source of water so the household can be represented by one person within a household. For sanitation this is only partially true. While it is unlikely that there are many different sanitation options, there is an individual choice for each member in the household to either use or not use available sanitation facilities. Anecdotal evidence during the survey indicated that there were differences in hygiene behaviour between different household members, man, women and children. This indicates that for hygiene behaviour and use of facilities, the household might not be the most adequate sampling unit. However using different sampling units in the same survey complicates data collection and analysis considerably.

For reasons described in Chapter 2 it seems justifiable to focus on the 'women of the household' who is generally responsible for the activities for which data is collected.

In extrapolating prevalence from a household survey to the population it is assumed that the average household size is similar whether the households are classified as having access or not, and being practitioners or not. Such assumption is made to avoid weighting the data for each household. In the Kenyan survey there was a concern that a large proportion of non-respondent households were single-man households. These households might not only be different but also over-weighted in the sample when converting outcomes for household to population[3] figures. Correcting the household weights in the analysis did not significantly change the prevalence for any of the outcomes in both the Kenyan and the Lao survey but two surveys is hardly enough to generalise such results.

9.2.2 Response and non-response

Initially Chapter 6 suggested documenting potential causes of bias such as non-coverage or non-response. This was to avoid the more complex methods of correcting for such factors within the analysis. However even describing these potential forms of bias requires a basic understanding of sampling probabilities which was not available within the organisations involved in the field trials.

9.2.3 Design effects

The research confirmed the high geographic clustering of WASH indicators by implementing a sector specific field trial. This high clustering was initially identified through analysis of existing data sets (Section 5.4.2.). This high clustering of the measures of interest results in high design effects (*deff*) and rates of homogeneity (*roh*) when cluster survey designs are used for data collection. These high values for *deff* and *roh* complicate representative sampling considerably and increase the overall cost of data collection by increasing the required number of clusters and overall sample size. As shown in Chapter 5 an increased value of *roh* will increase the minimum number of clusters required to achieve a given required precision of the prevalence estimate. Hardly any information was found in the literature regarding sampling highly clustered data although such situations are common, as shown in Chapter 5.

[3] Population is in this context not being used in its statistical sense as the collection of all BSUs (households) but as a group of individual people.

9.2.4 Stratification

When determining the sample size in Chapter 5 it was established by Montanari (1993) that *roh* could be used as population property under certain conditions.

One of the conditions mentioned in Chapter 5 was that the *allocation of PSU to the strata is proportional to the stratum sizes.*

The *WaSH* survey methodology aimed only to apply explicit stratification which means that for each stratum (e.g. rural, urban), a separate survey has to be done. This means that each survey has only one stratum and this condition would be fulfilled at all times. This approach was suggested on the assumption that the survey would require between 200 and 300 samples. With a sample size based on a 32 x 32 design such an approach will be difficult to maintain in the future as this design would have to be repeated for each stratum increasing the sample size considerably. Moreover, using a non-stratified sampling method might not be the best approach as stratified sample designs provide an increase in the precision of the outcome (Chapter 8). Moreover, merging unstratified datasets adds complexity to the survey methodology, particularly if the method is to be used by statistically untrained survey staff as is often the case.

Due to large sample sizes and financial constraints, the initial plan of a survey per strata was abandoned in field trials. Data on urban and rural strata was collected in the each survey keeping each PSU entirely in either stratum. The first stage sampling selected the PSU with a probability in proportion to the size of the PSU. This meant that the allocation of PSUs to the strata was proportional to the strata size, as required by Montanari (1993). It is unclear how unrepresentative *roh* would become if this rule were not respected. Explicitly upholding this rule in field surveys can significantly complicate data collection and weighting. With a wide variety of *deff* and *roh* among different surveys it might be that this rule is more of theoretical than of practical importance. However only more research would allow a decisive answer.

9.2.5 Weighting of data

When simplified "equal probability of selection method" (EPSeM) sampling methods are used there seems to be an illusion that no weighting has to be used at all. However if the obtained number of samples is not obtained or estimated values prove to be wrong, such a correction will be required (Fitch 2000). Applying weights to the samples has an impact on the value estimated, while cluster design only influences the confidence interval CI of the estimate. Weighting of samples is therefore more important than determining CI, as it influences the end result and can have an impact on the conclusions drawn from the survey. The field trials confirmed that concepts of selection probability and sample weighting are far more important than the concept of confidence interval which was contrary to the initial priorities set in the research project. This is dicussed below in section 9.3.

9.2.6 Cluster-sample cost ratio

The cluster-sample cost ratios in both trials were much lower the 450 estimated in Chapter 4. Kenya produced a cost ratio of 34 while the Lao trial had a cost ratio of 22. Table 9.1 below lists the different values calculated in Chapters 5 and 8.

Trial	C_{ratio}	b	c	n	cost	Δ_{cost}	Δ_n	Remarks
Kenya:	34	5	44	220	1716	+11%	-28%	
	34	9	37	333	1591	0%	0%	(optimal)
	34	18	34	612	1768	+11%	+100%	
	34	32	32	1024	2112	+33%	+235%	cxb Kenya trial
Laos:	22	3.5	49	172	1250	+9%	-42%	
	22	6	41	246	1148	0%	0%	(optimal)
	22	14	35	490	1260	+10%	+130%	
	22	33	32	1056	1760	+53%	+700%	cxb Lao trial
Ch 4:	450	10	37	370	17020	+10%	-64%	
	450	32	32	1024	15424	0%	0%	cxb theoretical
	450	95	31	2945	16895	+10%	+188%	

The rate of homogeneity and the precision of the estimate are kept constant in the table

Table 9.1: Comparison of cluster-sample cost ratios and the effect on survey cost and sample size

Although there are slight changes to the measured *roh* in the Lao survey this value is kept to 0.31 across the whole table for easy comparison. In Chapter 5 the rate of homogeneity determined the minimum number of clusters required to obtain a result within a given confidence interval. That confidence interval also determined all the possible 'take -cluster' combinations that were suitable to achieve this precision. The cost ratio between cluster cost and sample cost indicated the most economic combination, not taking into account practical constraints. As calculated in Chapter 5 all cluster-sample combinations (b x c) in Table 9.1 and consequently the sample size (n) will give the required 10% point confidence intervals for a *roh* equal to 0.31.

The lower cost ratio gives sample size requirements which are three to four times lower compared to those calculated in Chapter 5. The optimum sample size as shown in Table 9.1 is higher for the Kenyan survey than it is for the Lao survey. In both surveys, smaller samples could have achieved the same precision compared to the field trials but at a lower cost. Not only do the sample sizes differ but the choice of different combinations ($b \times c$) within 10% of the optimal cost decreases with a decreasing cost ratio C_{ratio}. This means that obtaining the right cluster x take combination will be more critical when the cost ratio becomes low. Table 9.1 shows that increasing the take increases the sample size but also that reducing sample sizes can increase the survey cost.

The cost model in Equation 4.19 which was used for calculating Table 9.1 is similar to the one presented by Kalton (1987). Kalton rightly remarked that such a cost model is an oversimplification of reality (Kalton 1987). It does not, according to Kalton, take in account practical considerations in data collection. Once the interviewer reaches the village it might be more economic to spend a whole day (or more days) at that location and do more exhaustive sampling (Kalton 1987).
The low cost ratios require a higher number of clusters to achieve low cost surveys. It would be worth testing how far these theoretical cost benefits can be obtained in field trials taking into account practical constraints. The low cost ratios also leave the door open for modified distance sampling methods as discussed in the next section.

Developing sampling without detailed sampling frames

As discussed in Chapter 5, existing methods of household sampling without detailed sample frames are not suitable for measures of interest such as WASH indicators mainly because of the high level of geographic clustering of the information. These methods lack a degree of randomisation which makes it difficult to develop or optimise these methods by traditional mathematics and statistics. To investigate this problem, the writer developed, together with colleagues, a sampling simulator in a GIS environment (Mann 2002) building on work by Lemeshow (1985) and Bennett (1994). The problem with simulations is that the conclusions of such an approach are restricted to the various situations simulated and generalising such findings requires an exhaustive set of simulations. As this exhaustive set of situations cannot be limited to situations for which real (collected) data is available there will be a need to resort to simulated populations. Doing this would require a better-designed simulator than the one resulting from this initial research project which was based on a GIS environment. To speed up the simulation process would require automation of several steps involved in these simulation process. Currently the process requires a lot of data manipulation and conversion which has to be done by an operator as explained in Annex L.

Redefining the simulation problem as an optimisation problem solves the problem of exhaustive sampling and leads to a faster understanding of the sampling method under various conditions as shown in Annex M (Bostoen 2006; 2007). To raise awareness about such problems, a conference on issues in survey methodology was held on 15 February 2006 at the London School of Hygiene and Tropical Medicine by the author and colleagues, and a follow up in collaboration with the Université Catholique de Louvain is being planned in Brussels on the fourth and fifth of June 2007.

To bring practical issues on survey methodologies to a wider public, the writer is currently working together with a colleague on a special issue of the journal of Emerging Themes in Epidemiology. This special issue of the journal, on which the writer is one of the two guest editors, will be available in April 2007.

9.2.7 Findings relating to sampling

There are four main findings relating to sampling. The first finding is that areas for which the need for data on access and practice is the greatest, rarely have adequate sample frames. This makes traditional cluster sampling as used in both Kenya and Laos trials difficult and expensive if not impossible. But even if these sample frames would be available the second finding is that most local organisations contacted during the research did not have any staff who understood the principles of representative sampling.

In this regard there has been a major shift by UN organisations in the water and sanitation sector. From the early 1980s until 2000 the WASH sector provided international organisations with sectoral data. During this period, efforts were made to strengthen the data collection capacity within the WASH sector and improve the quality of the gathered data. From 2000 onwards multidisciplinary national household surveys such as the DHS and MICS became the major source of data for the Joint Monitoring Programme. National household surveys do not require involvement of the WASH sector, which meant support of survey activities within the sector were not central any more to the JMP monitoring activities.

The third finding is that access and practice information for the WASH sector is highly clustered. This finding has several consequences. First, existing survey methodologies such as the EPI-sampling which do not required detailed sample frames are unsuitable for the sector[4] as they are not suitable for the collection of highly clustered information. Secondly high clustering requires an increase in the sample size to achieve a given precision. This results in an increase of the amount of data that has to be collected and processed during a survey. The need for more data makes the whole data collection process more cumbersome, which in turn makes organisations not used to such activities reluctant to get actively involved in data collection in the WASH sector.

The last of the four major findings on sampling is the cost ratio between the cost of single sample and the fixed cost of an extra cluster. These costs which are much lower first estimated in Chapter 5 allow for more clusters to be used in a clustered sample design without a high increase in the survey cost. But they also put into question the need for a cluster survey design. If a sample frame (or an alternative sampling method not requiring a sample frame would allow for simple random sample the cost, complexity and effort required to collect reliable data would be significantly reduced. Methods in biometrics which approximate simple random sampling could be considered for application in the WASH sector.

9.3 Analysis

Indicators → *Sampling* → ***Analysis*** → *Implementation protocol*

While there was little understanding of statistical analysis among the implementing partners there was even less awareness of the basic principles regarding sampling. This meant that in the best cases the partner organisation could use some simple

[4] They are suitable to estimate immunisation coverage for which they were designed.

statistical formulae although they were not acquainted with how to select formulae for a given situation. Moreover, they did not understand the risks involved when the correct formulae are used on non-representatives samples.

While suitable (free and commercial) software exists to simplify such complex analysis of survey data, none of the organisations were acquainted with any of it. This is a sign of how little rigorous data collection and analysis is done within the sector by such organisations. Although in the Kenya and the Lao surveys, staff were trained during the survey in the use of EPI-Info 2002, it is clear that without a minimum of statistical understanding such software is not a useful tool. After all these are tools to simplify analysis but they cannot substitute for a lack of statistical understanding.

From the field trials it was also clear that EPI-Info is not suitable for handling *WaSH* data as it is unable to compose, in a convenient way, the various *WaSH* indicators form the available data. Although not used in the trials, EPI-Data would be the software of choice in future. A recent version of this freely available software package allows for data analysis. Earlier versions of EPI-Data did not allow for analysis which was the only reason why EPI-Info was preferred in the in the field trials over EPI-Data.

Initial effort in analysing the *WaSH* survey methodology concentrated on getting the estimate right and obtaining accurate confidence intervals (CI). The CI were considered important to ensure that progress could be measured accurately and to ensure that measured differences could not be attributed to the sampling process. However in terms of priorities, CI proved to be far less important than sample weights. To get an accurate prevalence estimate, understanding sample weights is much more important than CI. As discussed before, they have an impact on the value of the estimate and are linked with understanding probability in the sampling process. Understanding sampling probabilities was seen as a priority in understanding the basic concepts in representative sampling.

9.3.1 Inference

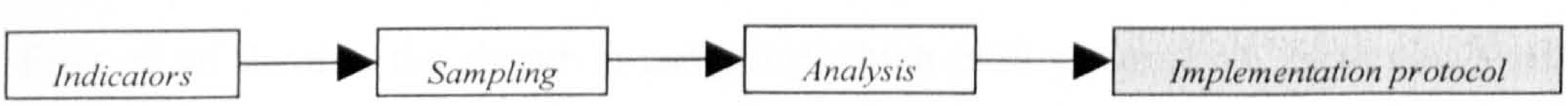
Although inference is a small step in the analysis it is an important one as it is based on assumptions which can only be determined by the staff involved in the sampling process. Inference can only be made if the sample analysed was representative and the sampling scheme taken into account in the analysis. During the field trials it became clear that that real probability samples only exist in textbooks. This echoes Fitch (1999) who stated at the 52nd session of the International Statistical Institute (ISI) that "*sampling efforts are not distinguished by being probability and non-probability, but by the extent to which the authors of the efforts use their integrity, knowledge and resources, to do well by the people they are to serve and this means making an effort to draw probability samples*". While inference does not require any technical manipulation it is an important step before proceeding to using the results obtained, and ill understood by practically all people involved in the trials.

9.3.2 Findings relating to analysis

Analysis of survey data has been significantly simplified by the advent of computers and statistical software. While simple but powerful statistical packages such as EPI-Data are made freely available, analysis of the survey data should be within any organisation's reach. However the software packages, as powerful as they are, cannot be a substitute for a lack of statistical training. Describing point by point how the analysis should be done might be possible but will be restricted to some software packages. Such an approach could help by making data entry sheets and scripts for analysis available to facilitate data entry and analysis. However, dependence on such approaches will also limit the organisation's ability to adapt the data collection and analysis tools to their specific need.

Simpler sampling methods could also simplify data analysis, particularly if they approximate simple random sampling.

9.4 Practical implementation



The implementation of the field trials presented in this thesis was done by professional bodies active in the water and sanitation sector. In Kosovo, the field work was done by the Institute of Public Health which is part of the Ministry of Health. While in Laos there were contacts with the Ministry of Health (responsible for access to water), the work was done by the Urban Research Institute within the Ministry of Communication Transport, Post and Construction (responsible for access to sanitation). Both the South African and Kenyan trials were done by consultancy organisations. Apart from the Kenyan trial, all staff were in-house staff members allocated to the field trial for the duration of the project. In Kenya, high school students were trained to collect the survey data while experienced observers were used for the collection of the validation data.

While all four organisations had been involved in data collection they had surprisingly little experience in the design and organisation of cross-sectional surveys. Most of the time, data collected by these organisations was not analysed by the organisation themselves but by external consultants or by collaboration institutions. In Laos there were no skilled staff available for structured observation as such activities had never done before in the country as far as the research institute was aware. Some staff members were trained to carry out structured observations. This proved challenging not only because of the short period available for training but in particular as the Lao culture has a strong sense of hospitality and privacy. This means that registering hygiene behaviours (without interaction between the surveyor and the surveyed) was awkward for both. Although not all households were keen on being observed, there were significantly less inhibitions regarding such activities by the households in the Kenyan survey.

The focus of the *WaSH* survey was initially on accurate indicators but was extended to correct sampling and reducing sampling errors. It emerged from the trials that the non-sampling errors were a largely underestimated problem. According to the literature, non-sampling errors are larger than the sampling errors. The sloppiness found in the field work was not only a cause of non-sampling errors but also indicated that people were uncomfortable with various aspects of data collection.

First of all there is the rigour in sampling which is ill understood, particularly when selected households are hard to find in the field and there are a lot of non-responding households. For example it was difficult for surveyors to grasp that selecting neighbours when a household is not available is bad practice.

Secondly the survey indicated unexpected problems with data collection. For example, surveyors needed a lot of convincing to observe the toilet of each household when it was not a public toilet. This objection was bigger in Laos compared to Kenya but on the other hand, the observations in Laos seemed to be more rigorous than those in Kenya.

Surveyors needed convincing to collect similar information in various ways during the same interview. When a question was asked, for example, they were not always willing to collect similar information by direct observations.
Contrary to expectations, surveyors found it difficult to distinguish only by observations the main differences between toilet technologies. They also struggled to link answers given by interviewees to predefined answers on the questionnaire - In particular to link different toilet technologies based on the answers given by interviewees. Therefore the surveyor was required to use some level of judgement as discussed in the sections above.
Thirdly, there were problems with the vast amounts of data which had to be collected and entered into a computer for analysis. The high sample size was the result of the one-stage cluster sample design and the high design effects found in water and sanitation data.

Motivating people in effective data collection proved difficult. It seems however, to be easier to convince inexperienced surveyors to be rigorous in their data collection than to convince 'experienced' people. Experienced people were less willing to do observations or to stick to the selected household. On reason might be that they had been involved in less rigorous convenience samples and found it hard to change their ways. Having an organisation such as NETWAS with training in its core of activities, improves the training of surveyors. They were efficient in assessing the training needs of their survey staff and fast in developing an adequate training schedule.

The four organisations were without any doubt keen to learn new data collection tools; however they found the rigour in which the tools should be applied cumbersome. While interested in WASH data collection, it was noted that for the organisations involved in the field trials in Kenya and Laos, such activities were not part of their regular activities. Neither organisation had an evidenced-based approach to their water and sanitation activities which was based on data they collected and analysed. Not using the data collected to guide activities could underlie the reluctance to stick to simple but rigorous rules in data collection to obtain accurate data. Without being convinced of the benefit of collecting accurate data and the use of collected data, there is unlikely to be any motivation to improve the accuracy of the data collection process.

In neither of the four trials could the survey organisations be convinced to undertake double data entry to reduce errors. It was not clear if this was because they did not care about the accuracy of the coded data or if they expected they could do the data entry without any errors. While some errors could be corrected through consistency checks, these consistency checks are in no way a valid alternative to double data entry. The only suitable alternative is technology-assisted data collection in which the collected data is digitised during the interview and merged to one big data-set. This avoids a manual transfer of data from a paper questionnaire to a computer, which accounts for a lot of errors.

During initial discussions on the questionnaire some partners insisted on using identical questions for drinking water and non-drinking water. While this was reluctantly accepted, this approach proved less confusing for the interviewers. The use of the same questions for different sources resulted in 'repetition' and a better flow of the interview.

During each survey, focus group discussions were held among a random sample of interviewees to assess their perceptions of the survey. Most results rely on the Kenyan focus group discussion which was more open compared to the group interview in the Lao survey.
The focus group in Kenya liked the short contact time of ±10min per household which was required for the survey. Participants that had been interviewed before in other surveys mentioned that most surveys took much longer and this interfered with their daily activities. All interviewers in every survey were found to be cordial. Interviewees did not have any preference for gender or age and did not find that for example the use of students in the Kenyan survey was a problem. The fact that an elder from the village accompanied and introduced every survey team increased the confidence of the interviewee to take part in the survey. They liked in particular the feedback at the end of the survey as they had never seen in other surveys what was done with the collected data. In Laos none of the villagers had ever been consulted in such a way so they did not have anything to compare it with.

Pocket voting and group discussion among surveyors in both the Kenya and Laos survey showed that if data becomes difficult to collect or the household difficult to locate a surveyor might even make up data rather than admitting there are problems in the data collecting process. This demonstrates clearly that the ease in which data can be collected will not only improve the data collected but also the willingness of the survey to do the effort of collecting that data accurately.

Technology-assisted data collection has some advantages which are worth considering, especially since such equipment is becoming more affordable .
These tools are mainly inexpensive computers adapted to the more arduous situations in which most surveys are held. Examples are cheap handheld computers such as the Simputer developed in India (www.simputer.org) and a hand-cranked laptop computer developed at the Massachusetts Institute of Technology (MIT), (laptop.media.mit.edu). They avoid the tedious data entry from paper-based surveys to electronic data sets. This conversion is very often a source of numerous errors. Moreover such technologies would allow for triangulation and verification of data at the household, and allow adding context-specific questions if this would be required. However dependence on such technology could stop the wider spread and regular use of survey methods when access to the required hardware is limited.

In the Laos survey, the survey organisers decided that the observers would conduct interviews when they finished their observations by 2 pm. This proved to be an error. While surveyors got to grips with the survey in one to two days, the observers never did and they introduced much more errors in the data collection than the 'full-time' interviewers did. It proved more useful to get observers involved in data entry and survey planning following their daily observation.

9.4.1 Findings relating practical implementation

There are two main findings relating to the practical implementation of the *WaSH* surveys. One is that many aspects, particularly those relating to the process of sampling, are too complex and implementing organisations often do not have the practical skill and experience to implement the *WaSH* survey in its current form.

One of the reasons might be that people involved in the sector are mainly engineers or related technical professionals with little exposure to evidence-based processes and statistical data collection and analysis.

It is also worth noting that currently data collection used by the JMP to report on the MDGs does not involve data collection within the WASH sector as it relies on multidisciplinary household surveys such as the DHS and MICS surveys.

The second finding is that the large amount of data to be handled, due to the sampling method, makes the method so cumbersome that it is unlikely that organisations will willingly adopt the survey method.

9.5 Dissemination

In Kenya and Laos, the surveys in which the author was directly involved, there was a willingness to make the data collected and the results obtained available to the community or at least their representatives. The first reason was that the data was always theirs in the first place and so they should be the custodians of the information. The second more important reason is that data could serve as a baseline for further studies or advocacy. Locations which have information available have often an advantage over areas for which no information is available when interventions are considered by external bodies.

9.5.1 Problem of data dissemination

During both trials it became clear that leaving data with the community requires the data to be well documented. This increases the chance that the data will be used again. To facilitate re-use of data the documentation efforts required far exceed those needed to document the survey results. The chance of other persons ever finding this data is remote, in particular without prior knowledge of its existence. The dataset made available to the community was the initial data set completed before cleaning and analysis. In neither of the two surveys was the data updated after leaving the country. Not only was there a lack of a suitable dissemination strategy to enable further use of the data, but the optical compact disk on which the data was 'burned' was unlikely to be a suitable medium for the environment in which it was stored. Although using a standard cross-platform computer format, the heat and humidity under which it was stored which would make the data unreadable within months after handing it over. While there is no doubt that there needs to be a link with the local community regarding data that is made available, it would be beneficial for the WASH sector to have a central depository (e.g. on the internet) where data can be documented or even made available. Such a depository could help in standardising data formats and document each data set for future use. It could also become a mechanism for standardising water and sanitation indicators in future.

9.6 Limitations of the research

The four surveys in this thesis, despite four distinctive different settings, hardly suffice to give conclusive information on how a water and sanitation sector-specific survey method should be designed. However it gives a wealth of information for further development of such a method. A considerable weakness which came to light early on in the development of a sector-specific survey methodology was the exclusion of local stakeholders interested in such a method as they are primary implementers of such a tool. Various meetings and trials have demonstrated that there is an interest in such methods, but the way the tool has been developed so far has led to little ownership by such organisations. The main reason for this was the lack of funding to even consult with these organisations. Their contribution was limited to participating in the initial WSSCC meeting of the monitoring task force on 18 June 2002 at the WSSCC headquarters in Geneva.

Such weaknesses become clearer when faced with the difficulties of writing out a protocol which is still evolving. Suggestions for further development and how to include such stakeholders in future developents are outlined in the recommendations section in Chapter 10.

9.7 Implications of the trials for future surveys

Developing the survey methodology each stone turned seemed to uncover another problem. With so many problems, it is important to focus on the most important problem raised. The problem of the implementation of a sector-specific survey methodology can be divided into two main components. One central component is related to the survey methodology. The second component is related to the knowledge and capacity of the organisation which should be involved in data collection.

9.7.1 Problems relating to the *WaSH* methodology

Problems relating to the methodology can be divided into two distinctive different problems; the problem of indicators and one of sampling method.

The problem indicators

While various components of the *WaSH* indicators could be validated in this research, none of the compound proxy indicators could be validated. The problem with WASH indicators is that with such complex and ill-defined measures of interest it is unlikely that a scientific consensus will obtain measurable proxy indicators. It is unlikley that proxy WASH indicators can be found which accurately express all critical aspects of access and practice in all possible circumstances, particularly if there is no clear gold standard to compare it with. For this reason other forms of consensus should be considered as recommended in the next chapter.

The problem of sampling

Compared to the indicator problem the sampling problem is more serious as it impacts at different levels. The current *WaSH* survey method only allows for sampling methods which require sample frames. This restricts the use of the *WaSH* method in situations in which a detailed listing of households is available. Many situations in which data collection is required do not allow for such sampling, so the method is very restrictive. In the Kenya and Laos surveys an alternative could be found which allowed for the collection of representative data, but theses required a good understanding of sampling probability which was not available among the implementing organisations.

Another problem is the high degree of geographic clustering of WASH information which requires a large number of clusters and a large sample size when traditional two step cluster surveys are used for data collection.

The large sample sizes required to achieve accurate results require handling of large amounts of data, which makes these methods unattractive to organisations not accustomed to such activities.

9.7.2 Problems relating to local capacity component

This component has two intertwined problems. First problem is one of the technical skills capacity while the second is one of capacity of implementation.

Technical capacity

None of the local organisations had the technical capacity to implement the current version of the *WaSH* survey methodology. The major problem is not so much the analysis which could be facilitated by free available software but the understanding of sampling methods and sampling probabilities. This problem is aggravated by the availability of sampling which is complex and often unsuitable for the situation in which it has to be implemented as explained above.

Capacity of implementation

The survey as it stands requires a lot of resources, mainly due to the large sample sizes required by the current available sampling methods. Large sample sizes are not only a problem of resources. The handling of a lot of data is so cumbersome that it is doubtful that local organisations would be interested to adapt such a method without clear benefits, particularly if they are strangers to this way of collecting and analysing information.

A simpler sampling method not requiring the inclusion of so many households in the sample would impact positively on three of the four problems referred to above and would make the adoption of such methods by implementation organisations more likely.

Chapter 10 draws overall conclusions from the research project and suggests some ways forward for future development of a sector-specific survey methodology.

CHAPTER 10 CONCLUSIONS AND RECOMMENDATIONS

The previous chapter summarised the findings of the study, and addressed various issues that limit the validity and applicability of the research. This chapter presents the final conclusions of the study which emerge from the sometimes conflicting evidence presented.

First, the nature of the monitoring problem is considered, illustrating the relevance of the concerns and questions that have driven the study. Next, the problems and solutions as developed in this thesis are explored, and some of the general conclusions about the use and limitations of the current *WaSH* survey method are presented. Based on these, recommendations are formulated to further develop a sector-specific survey methodology. These recommendations are placed in the context of current water and sanitation monitoring needs.

10.1 Nature of the monitoring problem

Initially the monitoring problem in the WASH sector was presented by WSSCC as a problem of indicators. However during the research each aspect of the survey methodology revealed additional issues. This made the idea of contributing to the problem of monitoring in the WASH sector more and more daunting. After identifying the problems of WASH indicators it became clear that the organisations involved in water and sanitation projects are often unfamiliar with the collection of statistically representative household samples and their analysis. This required widening the research topics to include to representative sampling and analysis. Analysing existing datasets such as DHS and MICS to determine suitable sampling strategies, identified high geographic clustering of the measures of interest. This high clustering was confirmed during field trials for this research. The only available sampling method found suitable for data collection in a *WaSH* survey methodology was a two stage EPSeM sampling strategy. The geographic clustering of water and sanitation data combined with preferred method of sampling required large sample sizes (1056 households) to obtain the required precision (s.e. ±10% points). However, such data collection was only possible in situations for which a sample frame was available. The lack of obvious sample frames in areas for which WASH data was required as well as the large amounts of data to be handled, complicated the data collection process and required the research to also address practical issues regarding data collection.

While there are many issues that constrain the overall data collection process, representative sampling was identified as the most serious problem facing a sector-specific survey methodology.

The development of a sector-specific survey methodology only served as a means to answer the research question as formulated at the start of the study. This question was whether people *untrained in survey methodologies* could measure in a *representative* way, and at *reasonable* cost, *summative* information on water sanitation and hygiene indicators in a *specified* region (Box 1.3).

The idea underlying the question was the creation of a methodology which could be so simple that it could be presented in a similar way to a recipe in a cookbook. Although the current research includes some parts of such a methodology it did not develop a method which was easy to implement. While further work is required, this research made progress towards the development of more suitable survey methods and represents to date the most advanced effort in developing a survey methodology for the WASH sector.

10.2 Problems and solutions

In Chapter 2 the study problem was divided into four constituent parts: indicators, sampling, analysis and implementation. This chapter has a similar structure in which problems and solutions for each part are discussed in turn.

10.2.1 Indicators

Since the beginning of the 1980's, professionals in the water, sanitation and hygiene behaviour sector have been searching for the holy grail of universal indicators. This is understandable as data currently collected are not always of good quality and are often not comparable between different areas or over a period of time. Terms such as access to 'improved' water or sanitation and 'improved' hygiene practices are commonly used in the WASH sector. This study demonstrates that what these terms imply is rarely clear. Lack of clear definitions for access and practice in the WASH sector makes it difficult to obtain consensus on measurable indicators.

Of the three indicators studied in this thesis, only the indicator measuring access to water and the indicator measuring access to sanitation could be partially validated in a scientific way. Focus groups of random selected interviewees, following each survey also accepted the water and sanitation indicators as used in the surveys. However these discussion groups did not accept the hygiene indicators used as they considered the resulting prevalence of 'improved' hygiene behaviour too high.

Defining an indicator for 'improved' hygiene behaviour proved to be the most difficult of all three. Field trials indicated that concentrating on handwashing as the only hygiene behaviour to be measured proved to be the best option, resulting in the least complex hygiene indicator. The presence of items required for handwashing (enabling environment) was used as a proxy indicator to measure the likelihood of handwashing with soap in the household. However all surveys had such a low handwashing compliance that validation of this indicator was almost impossible.

The sector-specific progress indicators developed in this thesis are a compromise between the *policy* that aims for a certain progress, the *welfare* that is the policy's ultimate goal, and the *feasibility* of the measurement. While it did not prove possible to obtain a scientific consensus for all aspects of each of the *WaSH* indicators there are other ways to obtain a consensus that achieves the desired policy aims.

Chapter 2 discussed three possible ways to achieve a consensus on *WaSH* indicators. The *scientific* consensus which is evidence-based was the one aspired to in this research. With such complex and ill-defined indicators, as well as a lack of a gold standard, such a consensus is unlikely to be achieved. A second consensus based on *consultation* is possible but would still be hampered by unclear definitions and the discord over the measure of interest. Moreover, there is the risk of endless disagreements on defining proxy indicators which are inherently imperfect approximations of a complex measure of interest. The most likely way forward is through *influential* consensus in which a critical mass of organisations, such as those represented in the JMP or its technical advisory committee, adopt indicators which are an improvement on those that are currently used. This would mirror the introduction of indicators currently used for the measurement of MDG target 10. Such a process does not necessarily exclude consultation among other stakeholders.

An *influential* consensus would mean that an agreement on water and sanitation indicators becomes a policy issue led by influential organisations in the water and sanitation sector. This allows for argumentative indicators rather than the science-based indicators which, as discussed, are unlikely to be achieved.

It must be noted that the *WaSH* indicators developed early in the research for testing in the field were already subjected to review and discussion by all the agencies involved in the JMP and WSSCC, whose suggestions were taken into account in the updated indicators tested in the field trials. This means that the water and sanitation indicators presented in this thesis emerged from an initial consensus of major players in the sector and could be resubmitted for approval.

10.2.2 Sampling

In developing the *WaSH* survey, considerable effort was devoted to sampling. This research established from existing data sets that *WaSH* indicators are highly clustered in most data sets. This finding was confirmed in sector-specific field trials during this research. This clustering greatly complicates the collection of representative samples as explained in Chapter 9. Cluster sampling using detailed sample frames is currently the only reliable sampling method available to the *WaSH* methodology. This traditional method of household sampling requires technical skills unavailable to the organisations which implemented the four field trials. Sampling is further complicated by the non-availability of a clear up-to-date and detailed sample frame in many settings where WASH data needs collecting. When only imperfect, incomplete or approximations of sample frames are available, an even more thorough understanding of sampling probabilities is required to exploit these in the generation and analysis of meaningful data.. These situations are often challenging even for experienced sampling statisticians.

Chapter 5 established a logical technique of determining the required sample size in which:

- *Roh* determines the minimum number of clusters required;

- The required precision of the estimate determines suitable combinations for cluster and take sizes;
- The ratio between cluster cost and sample cost determines which of these combinations are suitable to keep the survey cost low.

The high design effect found for the *WaSH* indicators requires a sample size of over 1000 households when using a cluster survey sampling design. The minimum number of clusters this entailed as calculated in Chapter 5 was 30. The relative large sample sizes require handling lots of data as discussed later.

What is urgently required to improve the convenience of a sector-specific survey method is a simple sampling method not involving detailed sampling frames. Such method should be suitable for situations with a high level of clustering. Distance sampling methods, which are well established in ecology, show some promise but would need further development before they are used in household surveys (Chapter 8). With the low cluster/sample cost ratio found in the Kenyan and Lao surveys (Chapter 8) such methods could approximate simple random sampling (SRS) which would reduce the sample size, increase the simplicity of the data collection and reduce the amount of data requiring handling. The major problem in developing such a sampling method is that while many would likely benefit from such a method, few want to invest in its development. Such practical sampling problems are of no interest to statisticians as many still considered such methods less rigorous than existing proven methods. On the other hand, these problems are seen as a statistical obstacle by the different disciplines which would benefit from such practical methods, even though the actual process of development may not be considered as part of any of those disciplines.

10.2.3 Analysis

As with representative sampling, the capacity of analysing data by the implementing organisations proved a serious obstacle in the development of a survey methodology. The current method requires manipulation of large amounts of records and there was in the four field trials little interest in becoming familiar with software that could facilitate such work. While the analysis of the end result is relatively simple, the creation of compound indicators was found difficult and required a good understanding of the software. To facilitate the use of the *WaSH* methodology software tools, such as entry forms and scripts can be made available. However that makes the method more rigid and prescriptive and its adaptation to the local situation more difficult as well as less likely. It is also clear that most organisations analyse their data as if they are from a SRS, regardless of how the data were actually collected. In this respect, the calculation of confidence intervals is not as important as understanding sample weights. Correcting sample weights can change the overall estimate if for example there is a significant non-response rate or when initial population figures proved incorrect. High non-response can compromise the rules of the equal probability of selection method (EPSeM) which results in a non-self-weighted sample. On the other hand using sample weights wrongly can result in incorrect estimates.

Chapter 6 recommends the documentation of possible biases rather than aiming to correct for them. But even simply documenting requires more understanding on probability of selection than is currently available in many of the survey agencies' portfolio.

10.2.4 Practical implementation

The study revealed that a lot of data on water and sanitation can be collected in a relatively short time. In the Laos and Kenya surveys, the contact time with the interviewer was around 10 minutes per household. Surveyors can be motivated to do rigorous data collection but when data collection becomes difficult, surveyors may start inventing information rather than collecting it. Spot observations need particular attention as they rely on judgements by the surveyor and a lot of preparation is required to ensure that results are comparable among surveyors. According to the implementing organisations the drawbacks which hinder the uptake of the current *WaSH* survey methodology are:

- complex sampling method;
- large number of household samples to be collected;
- large amount of data that needs to be entered in the computer;
- preparing data for analysis (combining data into the different indicators).

Three out of the four of these problems are directly linked to the sampling method used for household data collection. Hence, simplifying the sampling process would have positive impacts on the practical implementation of such a method.

10.3 General conclusions

In answer to the research question it is highly unlikely that people *untrained in survey methodologies* will be able to measure in a *representative* way, and at a *reasonable cost*, *summative* information on water sanitation and hygiene indicators in a *specified* region (Box 1.3) given the survey methods, and in particular the sampling methods, currently available.

While there are several reasons for this, the central problem are the sampling methods currently available which require a good understanding of sampling probabilities. Moreover, accurate sample frames are often not available and require creative application of sampling techniques to fit substitutes for these sample frames. There are different ways forwards to improve this situation, none of which are mutually exclusive.

The first way forward is to improve statistical understanding in the water and sanitation sector as a whole. The advantage would be that people involved in the sector would be able to design their own surveys and could fully participate in the development of a universal method for those less skilled in survey methodology. The likely disadvantage of such an approach would be the time and effort required to train people within the sector. Time would be particularly a problem with achievements of the MDG aimed at 2015.

Another problem would be determining which organisation would take the lead. While these efforts are required in the WASH sector statistics is not often seen within the remit of WASH organisations. International efforts to improve statistical skills are often focused on national statistics offices.

A second way forward is to make the sampling method more prescriptive. By this it is meant that the method can be followed as a recipe even if users are unfamiliar with the concepts of probability and representative sampling. Such an approach was attempted in this research however the complexities and limitation of the sampling methods did not allow for a convenient and simple recipe. The sampling in the current *WaSH* survey method can even be challenging for experienced survey statisticians. It is clear that more innovative methods have to be explored to solve this problem.

The sampling problem is a technical problem requiring technical solutions and a clear policy of funding agencies to invest in the development of such methods. It requires relatively limited scope, time and funding but carries the potential of a significant positive impact on the sector. Unfortunately, it demands commitment of a sector which might not see it as their responsibility to develop such methods.

Another reason for the negative answer on the research question is the lack of appropriate indicators required for measuring 'improved' access and practice. The indicator problem is however of a complete other nature than the sampling problem. WASH access and practice indicators are a simplification of a complex reality. They will always be approximations of a given situation and are for that reason very difficult to validate scientifically. For that reason this study concludes that setting WASH indicators for the purpose of comparing access and practice figures should be done by influential consensus amongst the major organisations in the WASH sector. Such indicators should to the greatest extent possible, be made based on the scientific evidence that is available and in discussion with other stakeholders; however the final decision should be a policy- rather than an evidence-based decision.

10.4 Recommendations

The design of a sector-specific method has been plagued with many problems. The most central of these problems is the **sampling method**. The lack of a suitable sampling method forms the biggest bottleneck in the development of a sector-specific survey methodology and the wide spread adoption of such a survey method.

Organisations such as Unicef, WHO and WSP should support the development of sampling methods which:

- take into account that sample frames are often not available in situations were the need for WASH data collection is the highest,

such as rural and peri-urban areas;
- are able to deal with a high level of geographical clustering of the measure of interest preferably avoiding large sample sizes;
- are straightforward and relatively easy to implement and analyse by people untrained in statistics and probability;
- are reliable, accurate and scientifically correct.

A conference on Methodological Issues in Field Surveys, London School of Hygiene and Tropical Medicine held in February 2006 identified that the need for such a method is not restricted to the water and sanitation sector but is a cross-disciplinary issue.

If such needs would be acknowledged in other disciplines efforts and expertise in finding an appropriate solutions could be combined.

The compound *WaSH* indicator in this thesis describes better the critical aspects of access to water and sanitation compared to the current universally accepted JMP indicators. However these *WaSH* indicators are only proxy-indicators aimed at describing the complex and multifaceted aspects of access to water and sanitation. Since proxy-indicators are by definition only approximations of a complex reality they are unlikely to be validated scientifically.

A universally accepted indicator should be achieved through policy decisions by the most influential organisations in the sector in collaboration with scientists and other partners in order to actively promote an acceptable and well documented set of argued indicators rather than seeking a purely scientific- or other evidence-base consensus.

Policy to develop sector-specific survey methodologies should not restrict itself to indicators and the sampling aspects of survey methodologies, but should also address practical implementation problems which would make such a methodology suitable and acceptable for those actively involved in the WASH sector.

This could be done by developing tools that can be used to facilitate data collection, be these data entry forms to be used with existing free data entry analysis software or tools to used practical tools such as technology-assisted data collection.
For a method to be accepted and adopted there is more needed than just the agreement on a methodology.

Programmes such as the Joint Monitoring Programme should actively address all the problems surrounding data collection in the Water and Sanitation sector and provide technical support for all facets of data collection in the sector.

While these three recommendations are likely to solve current major obstacles in measuring access and practice it is likely that other problems will emerge before the sector will be able to benefit from a robust sector-specific survey methodology. What is most needed is an organisation which advocates for improved monitoring in the sector. Not only for international advocacy, which is covered by the JMP, but mainly to allow practitioners in the sector to better target their limited resources and measure the impact their activities have. After all, progress is mainly made by experience staff on the ground when the right tools are available to them. This is in contrast to headquarter staff who merely aim to improve monitoring and stimulate such progress. Developing such measurement tools in the water and sanitation is likely to achieve analogous benefits to the development of a similar specific survey methods for WHO/Unicef's Extended Programme of Immunisation (EPI) which has achieved major progress in eradicating diseases such as measles and polio.

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A VISION 21 TARGETS FOR 2015 - 2025 AND MILLENNIUM DEVELOPMENT GOALS

A.1 Vision 21 suggested targets for 2015 and 2025

#	2015	2025
1	Universal public awareness of hygiene	Good hygiene practices universally applied
2	Percentage of people who lack adequate sanitation halved	Adequate sanitation for everyone
3	Percentage of people who lack safe water halved	Adequate water for everyone
4	80% of primary school children educated about hygiene	All primary school children educated about hygiene
5	All schools equipped with facilities for sanitation and handwashing	
6	Diarrhoeal diseases incidence reduced by 50%	Diarrhoeal disease incidence reduced by 80%

Source: {WSSCC, 2000 #102,p.35}

Table A.1: Vision 21 targets for 2015 and 2025

The first three targets and vision 21 have to be measured at the household level and are considered in this thesis. It was initially considered possible to collect information on target four at the household as well as at the school but this thesis proved that collection at the household was not realistic. Target five regards information which is best collected by school surveys and is as such not included in this thesis. Neither is target six included in this thesis as this as much a medical as an environmental health related target.

A.2 Millennium Development Goals (MDG)

Millennium Development Goal number seven (Table A.2) is directly related to water sanitation as shown below.

Millennium Development Goals
Goal 7: Ensure environmental sustainability;
Target 10: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation;
Indicator 30[1]: Proportion of people with sustainable access to an improved water source.
Indicator 31[2]: Proportion of people with access to improved sanitation.

Source: {UN, 2001 #226,p.57}

Table A.2: Millennium Development Goals relating to water and sanitation

The MDG Target 10 superseded intermediate targets two and three of V21

[1] Before the World Summit of Sustainable Development in Johannesburg this was indicator No. 29

[2] Before the World Summit of Sustainable Development in Johannesburg this was indicator No. 30 but at the time only related to slum dwellers under Target 11.

B WSH INDICATORS FOR EPHII

These were the first documents produced by the author for this research project. They were discussed by the WSSCC's monitoring task force held on the 18 June 2002 in Geneva. At the time the term *WaSH* indictors was not yet in use.

B.1 Draft list of indicator

The following annex is the initial drafted list of indicators to measure Vision 21 targets to be peer reviewed by the WSSCC monitoring task force.
This document contains various sources of data combined to three proxy indicators for three Vision 21 targets at household level. The outcome is a binomial value per household. The document also includes a list of assumptions made in relation to the outcomes.
The document attached is kept in its original format.

WSH Indicators for EPH II

Deadline: **31 May 2002**

Deliverables:

This document

- ***Draft list of indicators** to measure Vision 21 targets. (Ready for peer review.)*
  - Combined proxy indicators for the 3 Vision 21 targets at household level
  - Resulting in binomial value per Household
  - List of assumptions
- **Draft questionnaire**
- **Discussion paper** highlighting rationale and assumptions
  - Paper outlining approaches to field verification of the
  - assumptions and
  - testing of the questionnaire.

Comments or suggestion on this document or issues relating to it are welcomed:

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A Appropriate hygiene practices, multiple indicators

Section A, covers the indicators for Vision 21, Target 1. The adapted* version of this target is:

	Vision suggested targets for 2015	for 2025
1	*Halve the percentage of people not applying good hygiene practices.*	Good hygiene practices universally applied

For the purpose of Vision 21 we would suggest to define good hygiene practice by:

Day to day application of practices and habits reducing risk of faecal-oral transmission of pathogens.

This definition would focus on faecal-oral transmission as the biggest cause of hygiene-related morbidity and mortality (WHO 1992) largely preventable through access to water, adequate sanitation and hygiene practices. The 'hygiene practice' indicators used have been chosen to be as independent as possible from the access to water and sanitation indicators to avoid, for example, a lack of access to water automatically appearing to have consequences for hygiene behaviour/awareness. Although this is desirable, it is difficult due to the prominent place that water supply and sanitation facilities play in the hygiene practices of the household.

In this chapter there are 5 questions/observations of which minimum 3 have to be collected and a score calculated from positive versus negative behaviours. In this example it is suggested to be **min 2/3** or 67% positive behaviours which relates to 2 out of 3 (67%), 3 out of 4 (75%) 4 out 5 (80%). (see also Table 1 on page 393)

A.1

Question/Observation

Is there a system for hand washing available in the household or; Can the household get all the things necessary for hand washing out in 1 min.? (after being prompted!)

❑ **YES** ❑ **NO**

(Water and soap [or ash, sand] are present in the HH) (Unlikely that the HH practises hand washing)

Conclusion

If **no** we will conclude that hand washing (as a way of reducing faecal-oral transmission) is not normally practised in the household, if **yes** we will assume it is.

Rationale/assumptions

This question aims to see if water, a basin and any washing agent like soap, ash or sand is present in the HH. If these items can not be seen or shown when prompted by the interviewer it is unlikely that the household practices hand washing in such a way that it can be considered a good barrier for faecal-oral transmission of pathogens.

Remarks

An increase of hand washing will improve health in a household. This is because of its potential to reduce the number of pathogenic organisms on our hands. In many parts of the world hand washing is not perceived as related to health (Zeitlyn 1994; Hoque, Mahalanabis et al. 1995). One person might use several methods of hand washing during the day, for example: rub the left hand with mud and rinse it with water after defecation; pour water over the right hand before eating; rub hands, arms legs and feet with water before prayer; or wash hands along with other parts of the body with soap in the course of a daily bath (Hoque, Mahalanabis et al. 1995).

The question above only aims to identify households that are unlikely to practise hand washing ('no'-group) as a way of reducing faecal-oral transmission. The households included in the 'yes'-group will have the potential to practise 'proper' hand washing.

A more in depth alternative to this question could be a demonstration as suggested in question B.1.

* Reasons for suggesting this adaptation are covered in the discussion paper.

A.2

Observation

Are the hands, in particular the nails, of the interviewee clean?

❑ **YES** ❑ **NO**

(You can notice clean nails!) (The nails of the interviewee are visibly dirty!)

Conclusion

If **no** it is concluded that the interviewee does not practise hand washing on a regular basis.

Rationale/assumptions

It is assumed that the interviewee will have clean nails if she/he washes her/his hands regularly and properly. It is also assumed that this will be representative for the other members of the household, in particular children in the household under her/his care. We do not assume the reason for the cleanliness is for hygienic purposes, but we do assume it has the same result.

Remarks

This is a similar indicator to the one suggested in question A.1 and it is not clear which of the two might be best omitted if needed. Question A.1 measures more the potential of a practice while question A.2 measures the status without taking into account whether or not it is done for hygiene purposes. See also remarks on question A.1.

A.3

Question/Observation

What happened to the faeces the last time that your child defecated?

❑ **Left on the ground.** (Nothing is done with the faeces after defecation.)

❑ **Thrown outside the yard.** (Just scooped and removed from the compound e.g. thrown on a open rubbish dump.)

❑ **Thrown in the river.** (Thrown in any surface water source like e.g. river, stream, pond.)

❑ **Thrown in the toilet.** (Just scooped and disposed of in the toilet.)

❑ **Buried.** (Scooped, taken away and covered with soil.)

❑ **No small children.** (No small children defecating in our yard/house)

❑ **Other** (specify)..

If you can observe this practice during your interview note down it.

Conclusion

The first three answers are considered to be unhygienic practice, while the next two are considered 'good' practice.

Rationale/assumptions

Despite children's faeces having a higher pathogenic load they are considered by many people to be harmless. Here we measure behaviour regardless of whether it is hygiene motivated or not.
Asking the question with regard to children might make it less loaded.

Remarks

If a 'potty' is used it is the disposal of its contents that is relevant in the question.
This question is only relevant for households with children that are still under the care of a caretaker/mother in regard to sanitation. The household almost needs access to an excreta disposal facility to fulfil this condition. Even tough no access to sanitation might have a big impact on this question it was still considered worthwhile including in the questionnaire.

A.4

Observation

Are there children (human) and/or animal faeces in and around the HH area?

❑ **YES** ❑ **NO**

Conclusion If **no,** this is considered to be a sign of proper hygiene practices.
Rationale/assumptions As it is sometimes difficult to differentiate between human and animal waste, both are considered in the question.
Remarks Interviewers would be trained to exclude obvious animal excreta in the survey e.g. goat faeces. This question links up with question A.3 which also looks at children's faeces.

A.5

Question/Observation **What does the household use as a drawing mechanism for drinking water?** ❑ **Tap** (From piped water or tap on container) ❑ **Dedicated container** (e.g. cup should not be stored in the water container or on the floor) ❑ **Ladle** (Should not be stored on the floor) ❑ **Nothing specific** ❑ **Other** (specify)..

Conclusion The first three are seen as good practice.
Rationale/assumptions Most water stored at home gets polluted at the household level during use. If proper drawing methods are used at the household level it is considered that the risk of faecal contamination will be reduced dramatically.
Remarks Need for proper training of interviewers and the adaptation of local names e.g. ladle.

B Appropriate hygiene practices: hand washing demonstration.

This question is an alternative question for question A.1 on page 390. It was kept separately as it includes a demonstration and is divided into two parts which each have the same weight as the questions in section A.

B.1

Observation
Ask the interviewee to demonstrate hand washing as done after defecation.

Part 1

Did the collection of handwashing items take less than 1 min.? This includes fetching things like water, soap, ash or sand?	❑ YES	❑ NO
Is soap, ash or sand used for washing?	❑ YES	❑ NO

Part 2

Were both hands used together? In the case of a person rubbing only one hand mark NO!	❑ YES	❑ NO
Are both hands rubbed at least three times against each other?	❑ YES	❑ NO
Is at least one cup of water poured on hands for rinsing? If the hands are rinsed in a container and that water is NOT thrown away, answer NO!	❑ YES	❑ NO

Conclusion
If any of the answers are **no** the hygiene practice indicator will be negative for that part.
Rationale/assumptions
Despite having everything for washing hands it is only through proper rubbing with a washing agent and proper rinsing that will reduce the pathogenic load on the hands.
Remarks
This question is divided into two parts. The first one is similar to question A.1 while part is the evaluation on the handwashing itself. Each of the parts will be treated as if individual questions.

Scoring mechanisms for sections A and B:

No weights are given to the questions (with the exception of question B.1), as there is some indirect 'repetition' on some issues. A minimum of three questions has to be answered of which 2/3 have to be positive for this indicator to be positive. In table form this would give:

Amount of questions with a positive result in regards to Hygiene practise	*Amount of question and observations with a result.* 1	2	3	4	5	6	7
1	X	X	N (33%)	N (25%)	N (20%)	N (17%)	N (14%)
2	X	X	Y (67%)	N (50%)	N (40%)	N (33%)	N (29%)
3	X	X	Y (100%)	Y (75%)	N (60%)	N (50%)	N (43%)
4				Y (100%)	Y (80%)	Y (67%)	N (57%)
5					Y (100%)	Y (83%)	Y (71%)
6						Y (100%)	Y (85%)
7							Y (100%)

X results in non-response
Y/N means does/doesn't apply hygiene practices.
(%) 'percentage of good practices'.
Good Hygiene Practice.
No Good hygiene practice

Table 1: Table format of decision model on hygiene practices.

Horizontal are mentioned the number of questions answered. If there at least 3 questions answered the table can give a result. In the unlikely event this is not the case the value would be like a non response. Once the right column selected the row is selected with the number of positive responses in regards to hygiene practice. The colour in the selected cell will indicate if good hygiene practices are applied in the selected household. In the example below 5 questions were answered and 4 indicators were positive (corresponding with good hygiene practices).

Amount of questions with a positive result in regards to Hygiene practise	Amount of question and observations with a result: 1	2	3	4	5	6	7
1	X	X	N (33%)	N (25%)	N (20%)	N (17%)	N (14%)
2	X	X	Y (67%)	N (50%)	N (40%)	N (33%)	N (29%)
3	X	X	Y (100%)	Y (75%)	N (60%)	N (50%)	N (43%)
4				Y (100%)	Y (80%)	Y (67%)	N (57%)
5					Y (100%)	Y (83%)	Y (71%)
6						Y (100%)	Y (85%)
7							Y (100%)

X results in non-response
Y/N means does/doesn't apply hygiene practices.
(%) 'percentage of good practices'.

Example of the use of table 1.

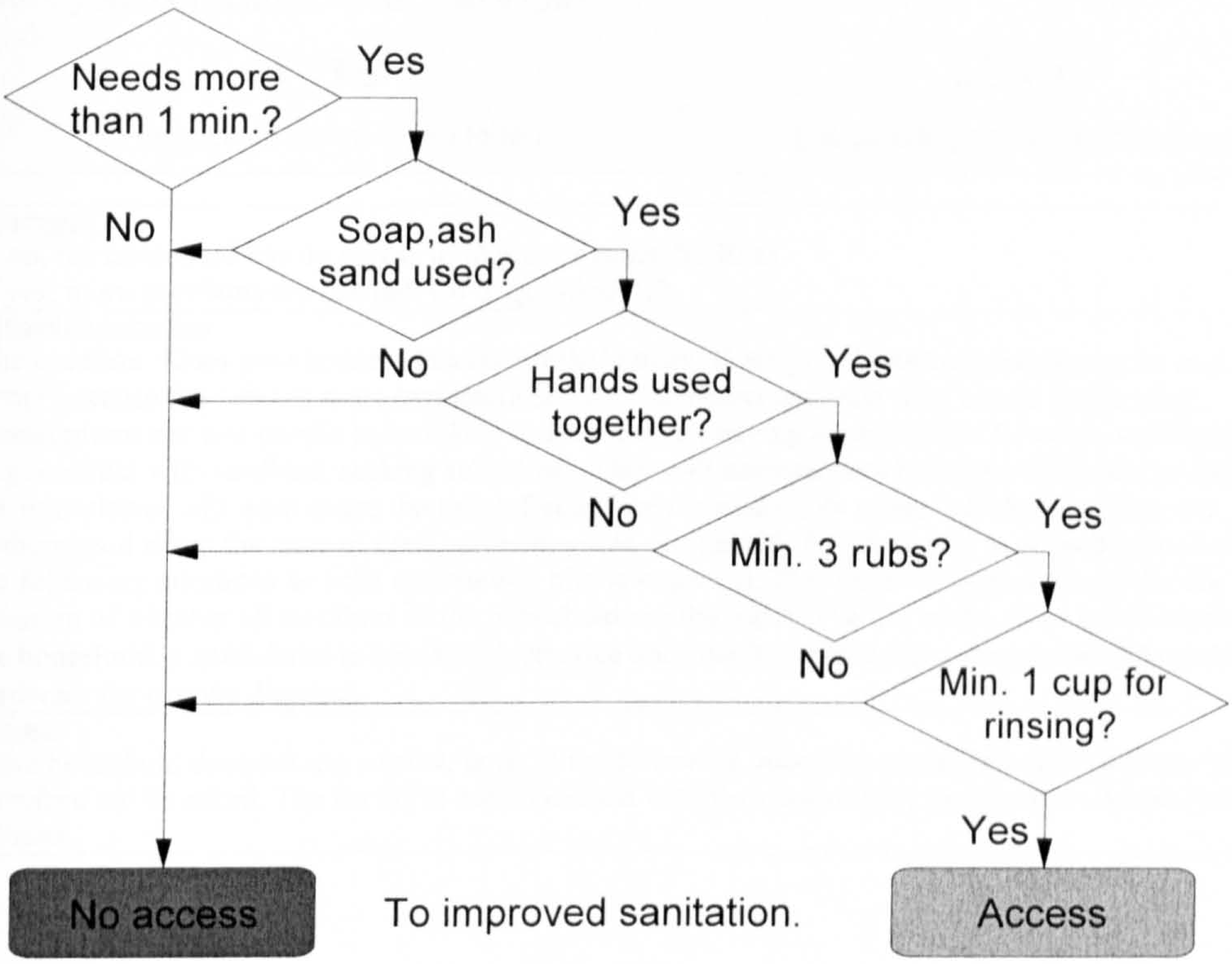

Figure 1: Flowchart model of decision model on hand washing (Question B.1).

Water and soap present?	Soap, ash and sand	Both hands used?	Minimum 3 rubs?	Min. 1 cup used to rinse?	No access?
No					No
	No				No
		No			No
			No		No
				No	No

Table 2: Decision model on hand washing (Question B.1) in table format.

C Access to improved sanitation

Section C, covers the indicators for vision 21, Target 2. The adapted* version of this target is:

	Vision suggested targets for 2015	for 2025
2	Percentage of people who lack *improved* sanitation halved	*Improved* sanitation for everyone

Sanitation here is seen in its narrowest definition as euphemism for 'human excreta disposal' and will be regarded as such in the rest of the document.
In the Global Assessment (WHO and UNICEF 2000) an excreta disposal system is *'improved'* when:

- It is private or shared but NOT public and if;
- It hygienically separates human excreta from human contact.

The relation between the 6 indicator in relation the outcome for target 2 is described below as a flow chart in Figure 2 and in Table 3.
C.1

Question

Does your household/family use a toilet?

❑ **YES** (household claims to use toilet)

❑ **NO** (Household practice open defecation)

Conclusion

If **no**, the household has no access to improved toilet facilities.
If **yes**, more questions are needed. Go to question C.2.

Rationale/assumptions

The question 'Does your household *uses* a toilet' rather 'Does your household *has access* to one' is better because the latter is more hypothetical. Use is a clearer question than access at this stage. Assumptions are that people are unlikely to lie about not having access unless for social-cultural reasons (e.g. conflict with landlord, seeking subsidies). They will normally not be informed about the fact that the interviewer will want to see the toilet. Even if they would really claim "no" because they are embarrassed about the state of their latrine it would not classify for 'access to improved sanitation' in the following questions so little interviewee bias is expected. This question does not consider the question of whether all members of the household use the toilet. The use of the toilet by all members of the household is considered to be a health practice once the household has access to the appropriate hardware for excreta disposal.

Remarks

If the household does not use a toilet, none of the following questions on sanitation are relevant and will, therefore not be asked. The survey is not concerned with the reasons why people do or do not use latrines.

* Reasons for suggesting this adaptation are covered in the discussion paper.

C.2

Question

Is the toilet your household uses:

❑ **Private** … used only by your family;

❑ **Shared** … used by more families but they are known to you;

❑ **Public** … available for use by anybody.

Conclusion

If the answer is **Private** it is considered that the household has access to improved toilet facilities but more questions are needed to confirm this. Go to question C.3 to check if the toilet is really used.
If the latrines are **shared** or **public** they will not be considered as 'improved' sanitation.

Rationale/assumptions

Definitions of private, shared and public are in relation to use and not to ownership of the latrine. It is considered that if the toilet facilities are not private, people do not have access. This is because of the risk that **shared latrines** are more likely to be less hygienic, and because safe use, especially at night for women and children, will be more problematic. For **public latrines** this problem is considered to be greater so public latrines are not considered as 'improved'.

Remarks

The question above is in relation to use and not on ownership.
During the GA2000 (WHO and UNICEF 2000) shared latrines were considered '*improved*' form of sanitation. This was due to the use of existing databases in which it was not always possible to differentiate between shared and private latrines. According to the JMP (Henderson 2002) shared latrines are not considered improved. If asking this question directly to the interviewee is not seen appropriate 'child' can be used to replace 'household' in the question.
Where the answer is **not private** no other answers are considered in relation to the questionnaire on sanitation. It is suggested the questions would still be asked in order to avoid the interviewer having a bias toward this choice in order to speed up their interviews.
As only private latrines are considered as improved the question on distance can be omitted.

C.3

Observation

Does the toilet show signs of regular use and good access?

(If a key had to be found or people needed more time than just the time to walk to the toilet, mark "no")

❑ **YES**	❑ **NO**
(It is being used regularly)	(It is not being used or is difficult to access)

Conclusion

If **no**, the latrine is not used it can not be considered as 'improved' sanitation
If **yes**, some additional questions will be asked to see if it is properly used.

Rationale/assumptions

If a locked latrine cannot be opened directly or e.g. the path to the latrine is overgrown, it is clear that other means of excreta disposal are used which for the purpose of the survey will be assumed 'not improved'
Proof of use of the toilet is probably the most powerful indicator of all in relation to access. Use of a sanitation facility indicates that the toilet probably:

- Is socially acceptable for the users;
- Provides the safety required;
- Offers the comfort needed;
- Can be run at an acceptable cost.

It will unfortunately not indicate if the excreta of the whole household (e.g. women, children, mother-in-law and babies) are deposited in the toilet.

Remarks

If the toilet is not used, this might be for a wide variety of reasons. Analysis of the causes falls outside the scope of this survey. The latrine might not fulfil all the above criteria for all potential users in the household. It will unfortunately not be possible to consider this in this survey.

C.4

Question/Observation
Is the toilet clean from excreta around the drop hole/closet?
❑ **YES** (It is clean) ❑ **NO** (It is not clean)

Conclusion
If **no** the way the latrine is used and/or maintained does not allow it to be considered as 'improved' If **yes** the type of latrine will have to be considered, see question C.5.
Rationale/assumptions
If the latrine is not used in such a way that it 'hygienically separates human excreta from human contact' it can not be considered an improved means of excreta disposal. This could be due to inappropriate design.
Remarks
It will be important to standardise observations through pictures and real observation during the training of the interviewers.

C.5

Question/Observation	
What type of latrine is used?	
❑ **Bucket** or service latrine	(Has to be emptied regularly and transported for disposal)
❑ **Overhung** latrine	(Latrine built over river or pond)
❑ **Open pit** latrine	(Is not covered and has no clear drop hole that could be covered)
❑ **Pit** latrine **with floor**	(Pit that is covered with a floor and has a clear drop hole)
❑ **Flush** toilet	(Water from a cistern or poured by hand is needed to flush the toilet)
❑ **Other** (specify)..	

Conclusion
If answers are **bucket, overhung** or **open latrine** there is no access to improved sanitation due to the technology used. If it is a **pit latrine with floor** it is considered improved. In the case of **flush latrines** there is an additional question on discharge; see question C.6
Rationale/assumptions
Faeces in **bucket or service latrines** have to be collected regularly. It is assumed that this is done by hand and transport happens via public roads. This means that the technology does not 'hygienically separate human excreta from human contact'. **Open pit latrines** are unlikely to be hygienic and rarely used by young children because of the danger or fear of falling in. **Overhung** latrines directly pollute surface water sources, which makes them a danger e.g. for people downstream in the case of a river. **Pit latrines** with a proper floor tend to be a suitable solution to hygienic excreta disposal. **Flush latrines** can be an improved way of disposing of excreta if the household has access to non-drinking water so they can flush properly and if the effluent of the latrine is disposed of properly. (see also question C.6)
Remarks
Information on access to non-drinking water, with regard to flush latrines is sought elsewhere in the questionnaire. If there is no access to non-drinking water (see question D.2) flush latrines will not be considered improved sanitation. N.B. If emptying of bucket latrines is mechanised and the contents are disposed of properly, it might be considered as a proper disposal method.

C.6

Question/Observation
If a flush latrine is used; **Are there any signs of discharge of effluent to (open drains) or surface water?** ❑ **YES** (Effluent is discharged in open drain or water source) ❑ **NO** (No signs of discharge.)

Conclusion
If **yes** the flush latrine is not an improved method of excreta disposal.
Rationale/assumptions
If the discharge is not properly disposed of it can be a hazard and human contact with excreta can not be excluded. In particular if the grey water reaches surface water source.
Remarks
Non sign of appropriate discharge does not mean that there is appropriate discharge. This was a question suggested in the feedback received from the issues paper but it is felt that it will exclude most of the flush latrines. Running this test e.g. in Brussels were al the sewage is dumped without treatment in the canal would mean the whole of Brussels has no access to sanitation. It is worth a discussion.

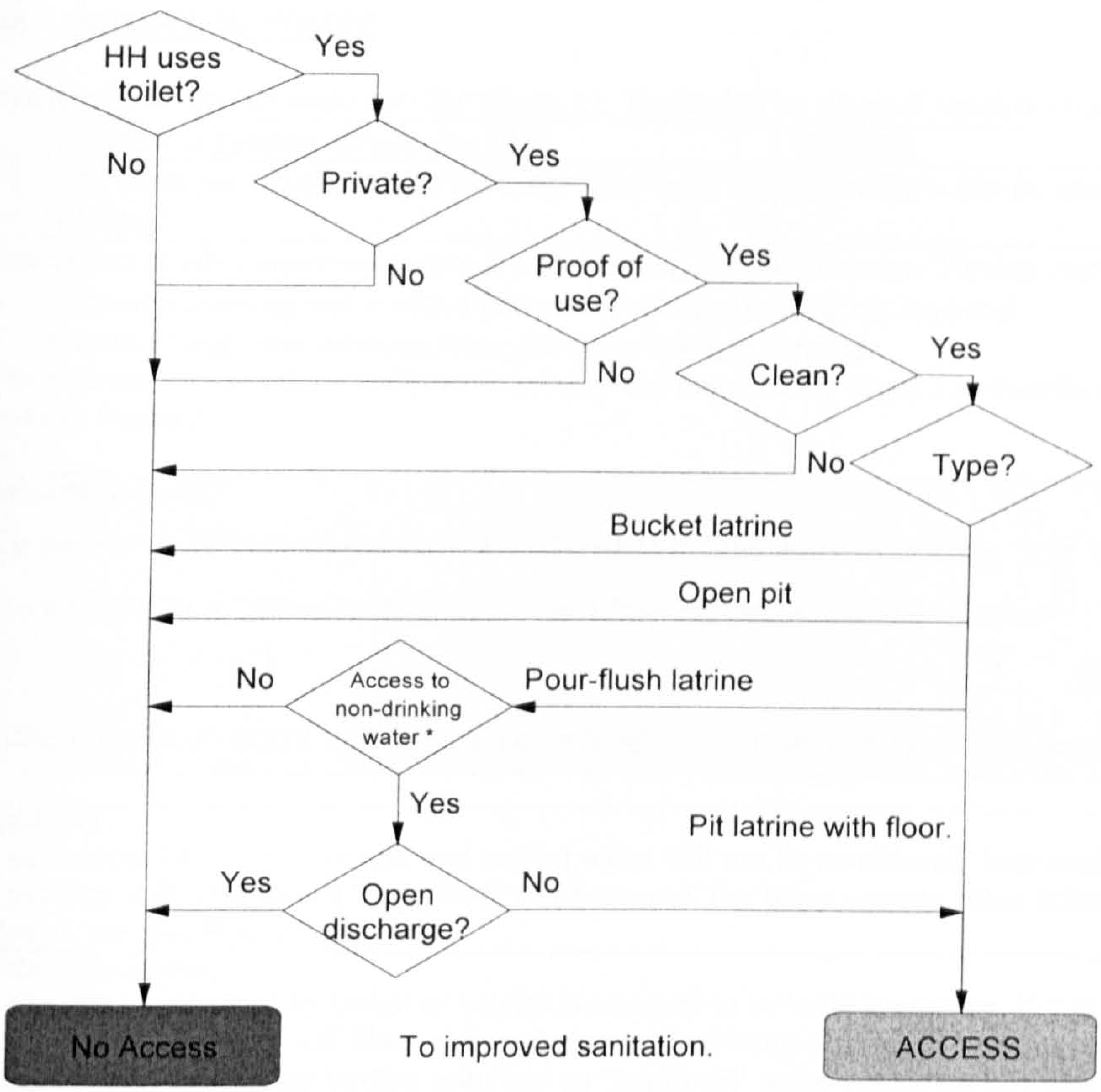

Figure 2: Flowchart format of decision model on improved sanitation.

HH use toilet?	Private use?	Proof of use?	Clean?	Type	(access to non drinking water*)	Open discharge?	ACCESS
N							N
Y	Public						N
Y	Shared						N
Y	Private	N					N
Y	Private	Y	N				N
Y	Private	Y	Y	Bucket			N
Y	Private	Y	Y	Open Pit			N
Y	Private	Y	Y	Pit with slab			**Y**
Y	Private	Y	Y	Flush	N		N
Y	Private	Y	Y	Flush	Y	Y	N
Y	Private	Y	Y	Flush	Y	N	**Y**

Table 3: Table format of decision model on improved sanitation.

* This information is available somewhere else in the survey and will be used when analysing.

D Access to water

Section D, covers the indicators for Vision 21, Target 3. The adapted* version of this target is:

	Vision suggested targets for 2015	for 2025
3	Percentages of people who lack *improved* water halved	*Improved* water for everyone

Discussion of what *improved* means is still an issue. In this document 'Having improved water means:

- Consume drinking water with a potentially reduced pathogenic load and
- Obtain enough non-drinking water for basic hygiene purposes.

The relation between the 6 indicator in relation the outcome for target 3 is described below as a flow chart in Figure 3.

D.1

Question/Observation

Do you use different sources for drinking and non-drinking (e.g. washing) **water?**

Exclude water for irrigation, livestock or other non-domestic uses as non drinking water!

❑ **YES** (Our water for drinking is different than for washing)

❑ **NO** (Our water for drinking and washing is the same)

Conclusion

If **no** sources like tanker, vendor and bottled water will **not** be considered 'improved' water sources. If **yes** they will be assumed 'improved' water sources. For other sources, other information will be needed, see also Figure 3 page 404

Rationale/assumptions

Water that is delivered by tanker or vendor is assumed to be more expensive. If it is the only source of water the elevated cost will likely reduce the amount of water purchased for hygiene practices. This makes tanker, vendor and bottled water not an 'improved' water source for HH who have no alternative non-drinking water source.
If there is an alternative for non-drinking water to the household then it will be assumed that they purchase this more expensive water because of its 'improved' quality.

Remarks

None

D.2

Question/Observation

How many minutes did it take to collect (non)-drinking water last time you went?
(Return trip, going and back! Non-drinking water is the water you use for washing!)

...... min To go and come back from the water source queuing included!

Conclusion

If less or equal to 30 min the household has access **if** the source is considered an improved water source.

Rationale/assumptions

It has been shown (Cairncross and Feachem 1993) that if between 3 to 30 min time is needed (round trip) for water collection the amount of water collected varies little with the distance. If more time is needed the of collected water amount drops.
The time we want to measure in this question is the time spent going and coming back from the source plus the time spent queuing and pumping. Activities such as socialising (unless done while queuing) and washing cloths at the source are to be excluded from the time measured.
The assumptions are:

- People are good in estimating time.
- Difference in altitude between household and source or difficult paths will partially be represented by the extra time needed to collect the water;
- Effort to abstract water such as pumping will be represented in the water collection time.

Remarks

During the preparation for the survey interviewers will have to be trained to obtain the correct time.

* Reasons for suggesting this adaptation are covered in the discussion paper.

D.3

Question/Observation

Source of water usually used for drinking?

- ❑ **Surface water** (Water from rivers, canals, lakes, ponds, ground based rain catchments etc.)
- ❑ **Rainwater** (House roof based rain water catchment. (i.e. not ground based)
- ❑ **Ground water** (Boreholes, wells, hand-dug wells, infiltration wells and galleries)
- ❑ **Piped water** (Tap at home or in the yard, public tap-stand, neighbour's tap)
- ❑ **Spring water** (Spring, artesian well etc.)
- ❑ **Tanker/vendor** (Water sold at or close to the house by mobile vendor)
- ❑ **Bottled water** (Factory bottled drinking water)
- ❑ **Other**(specify)..

Conclusion Most of the conclusions depend on other answers (See Figure 3) and for that reason are not mentioned here.
Rationale/assumptions Each source has a likelihood of contamination based on its type but also on the way it is protected.
Remarks *Surface water* Surface waters include lakes ponds, rivers, streams, canals, dams. They tend to be the most polluted and are not considered as an improved water source for drinking water if they not treated before drinking. Large ground-based rainwater cathments or hafirs will be considered in this category because of their water quality. *Spring water and artesian well* Water from a spring is considered as an improved water source if a covered spring box protects the spring. Getting the right information of the spring protection at the household level will be difficult which makes this type of information unreliable. The diagnostic question to identify whether the water point is a spring is to ask whether the source has continuous flow. To check if it is protected is to ask if any concrete was used around the source or the water comes from a pipe or channel. If not protected this source will not be considered improved. *Ground water* Ground water sources like wells and boreholes (Hand or machine made) are generally sources of good drinking water quality needing no treatment. The main potential source of pollution is through the same hole the water is abstracted. This can be due to the abstraction method or from run-off water if no proper protection is provided. Again this is difficult to assess at household level. There are some ways in which water collection is more likely to pollute the water source than others. For that reason it is suggested that if groundwater is pumped by hand or mechanically, it is considered an improved water source. If water is collected by bucket, bag or other recipient, it is not considered to be an improved water source unless the water is treated for drinking. Infiltration wells will for our purpose be considered as wells, as they will provide similar qualities of water if they are properly built. *Rainwater* Household rainwater (roof) catchments are considered an improved water source. Large ground based rainwater catchments are not considered improved, as was mentioned above. *Piped or tap water* Only if the water is on for most of the day is it considered improved. Intermittent sources will be discussed below. In this survey public stand-posts will be considered in this category when the y supply piped water at the public tap-stand. There is an assumption that if the water source is not intermittent the quality will be improved. This might need checking in some cases. *Tanker truck, vendor* In this case the vendor is considered a mobile vendor and not a static vendor. Households buying water from a fixed vendor are considered under the above categories, according to the type of source de vendor uses. In this survey, a vendor is anybody delivering water to the household. *Bottled water* Water sold in bottles and filled in an industrial facility.

D.4

Question/Observation (Only for groundwater sources) **Do you use any kind of pump (manual or motorised) to get your water?** ❑ **YES** ❑ **NO**

Conclusion If **yes** the source is considered a protected and improved water source.
Rationale/assumptions In this question it is assumed that if the water is obtained through pumping it is most likely a source that is properly protected. It assumes as well that not many unprotected sources have pumps. This is an assumption that needs verifying, however experience suggests that it is general true. (Discussion on verifying might be needed.)
Remarks Collecting information on the way the source is protected can prove difficult because the household may not know, and the protection may not be visible.

D.5

Question/Observation (alternative question) (Only for groundwater sources and springs) **Has the source you use any cemented wall or platform (cover) as protection?** ❑ **YES** ❑ **NO** ❑ Don't know

Conclusion If **yes** the source is considered a protected and improved water source.
Rationale/assumptions This question is a more direct alternative to the question above in regard to groundwater and spring water. It is assumed that run-off water is the most important potential source of pollution.
Remarks For groundwater sources either question D.4 or D.5 should be used

D.6

Question/Observation (Only for households getting piped water or water from a tap.) **For how many hours during daytime-per day is water NOT available?** **...... Hours** ❑ Always water E.g. any time I turn on the tap there is water!

Conclusion If more than 6 hours (¼ of 24h) per day the source is not considered an improved water source.
Rationale/assumptions No water distribution network is free from leaks, but as long as the network is under pressure the chance of pollution getting into the network is low. If however the water pressure in the networks drops, pollution can get into the distribution network. If the source becomes intermittent the risk of pollution increases with each cycle of intermitted pressure in the network. For that reason intermittent piped water sources are not considered improved.
Remarks 6 hours is just chosen as ¼ of 24h day but is arbitrary and not based on any scientific evidence.

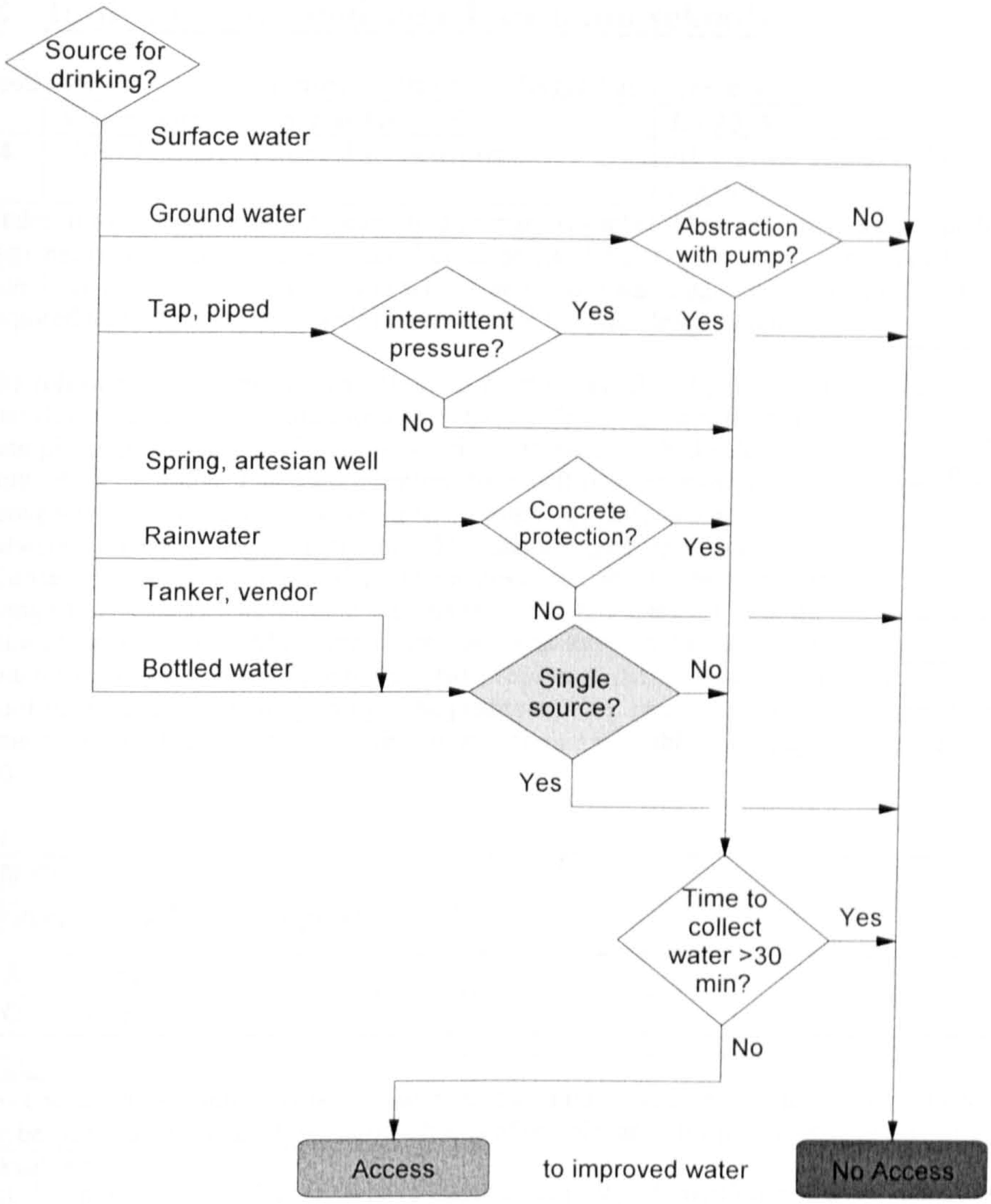

Figure 3: Flowchart format of decision model on access to improved water sources.

E Indicators for hygiene educationin schools

Section E, covers the indicators of Vision 21, Target 4 as shown below.

	Vision suggested targets for 2015	for 2025
4	80% of children educated about hygiene	All primary school children educated about hygiene.

Under this target we will understand that primary school children can prove a basic understanding of hygiene. If children can demonstrate their understanding of hygiene practices this will prove that they have been taught this, most likely at school, and that it was taught properly. It is the knowledge acquired that might improve their behaviour, not the knowledge taught.

The following questions are read aloud in front of the class by a trained interviewer. Each of the questions will have a letter as shown on the example answer sheet in Figure 4 which correspond with the letter in front of the question. For each question there will only be two possible answers which will have an '**x**' or an '**o**' as marking. Only one of the two answers is clearly the best answer. The student gets maximum **one minute** to answer each question. Once answered the student cannot change the answer. The student will have to put the marking into the relevant answers box. Minimum three questions have to be answered. Two thirds of the answers have to be correct for the student to have given proof of good understanding in hygiene practices. This gives exactly the same scoring table as used in section A and shown in Table 1 on page 393.

Question	Answer
A	X
B	X
C	O
D	X
E	O
F	X
G	O

Figure 4 : Answer sheet

E.1

Question
A) Are you a boy or a girl?
X Boy
O Girl

Conclusion
No conclusion, warming up question to make the children at ease with the system. If encoded it could maybe be used later in analyses although it is of no relevance for the purpose of this survey.
Rationale/assumptions
Probably none of the students will have had a similar way of questioning before so they might be uncomfortable with the system.
Remarks
None

E.2

Question
B) What is best, washing your hands before or after eating?
X Before
O After

Rationale/assumptions
Although handwashing is practised before and after eating, the two practices are for 'different' reasons. It is the handwashing before the meal, which is most relevant to hygiene practice as it, reduces the risk of faecal-oral transmission.
Remarks
None

E.3

Question **C) Which water is healthier for drinking; from the river or from the hand-pump?**	
X	River, pond, ground level rainwater catchment…
O	Hand-pump, mechanical pump, roof rainwater catchmet, (Piped water?)

Rationale/assumptions
Water sources in the question should be adapted to the type of sources available in the area. They should also be described in such a way that the students can easily recognise and distinguish the type of water source.
Remarks Interviewer can describe in few words the two different sources in the question.

E.4

Question **D) Is it better for your health, to wash hands before or after going to the toilet?**	
X	Before
O	After

Rationale/assumptions
It is only the handwashing after defecation that is a good barrier to the spread of pathogens.
Remarks No extra information should be given.

E.5

Question **E) Can you get sick/unwell from flies on your food?**	
X	No
O	Yes

Rationale/assumptions
Flies are considered a nuisance but are not always seen as the health problem they are. The question is asked to see if they link the two things together.
Remarks No extra information should be given.

E.6

Question **F) Why should you wash your hands with soap (ash, sand)?**	
X	Because you mum/ dad tells you.
O	Because it is good for your health.

Rationale/assumptions
If this question is answered wrongly it is considered doubtful that any education has been given. Motivation for handwashing would therefore not be the best possible and it would shows little understanding of hygiene.
Remarks No extra information should be given.

E.7

Question

G) The best way of washing hands after going to the toilet is with the hands apart (e.g. only the left hand) or with both hands together?

X	Apart, e.g. One hand only
O	Together

Rationale/assumptions

A large part of the world still separates the functions of both hands and washes them separately. For handwashing, the rubbing activity is the most important in removing pathogens from the hands. Rubbing both hands together is the only proper way of washing hands.

Remarks

Interviewer can demonstrated the two options to clarify the question.
This question will have to be asked after question E.4 as it gives the answer to the question.

E.8

Question

G) What should be done with the excreta of all young children such as your little brother's or sister's?

X	Don't touch it and every body should leave it where it is?
O	Somebody has to put in a toilet or bury it?

Rationale/assumptions

There might be a problem if the parents for hygiene reason do not want the children to dispose of the excreta but rather do it themselves. This can be resolved by the way the question is asked by the trained interviewer.

Remarks

Interviewer can demonstrate the two options to clarify the question.

F Indicators for access to improved sanitation in schools

Section F covers to indicators for vision 21 Target 5 as described below.

	Vision suggested targets for 2015
5	All schools equipped with facilities for sanitation and hand-washing

The indicators are ① the percentage of school children that have access to improved sanitation, and ② the number of handwashing point in regards to the number of toilets. Both of the outcomes have to be 100% or higher for the school to have access to improved sanitation.

Access to improved sanitation.

First of all one has to find out how many boys and how many girls have recreation at the same time. If all classes have recreation at the same time this figure will be the number of girls and boys 'registered' in the school. If in doubt assume this is the case. Lets call this amount for girls 'g' and for boys 'b' and fill the values into the table on the right. Add to the table 'q' which is the maximum amount of children per toilet. If there is no national standard for this, use max 25* persons per toilet See also discussion paper). What is also needed is The girls need separate toilets from the boys. (check if there are national standards) If there no separate toilets for girls mark tag=0. If not mark the amount of latrines available to girls, given the following definition in the table.

b=	Boys
g=	Girls
q=	Pers./toilet

Cubicles for boys or girls are only counted if they:

- have a superstructure that gives enough privacy (e.g. proper door, walls etc.).
  - are a pit latrine with floor and a small drop hole or.
  - are flush latrine and water for flushing is available.
- The toilet is clean around the drop hole/closet.
- They are no further than ±50** meters/paces away from the building.

The number of improved toilets available to the boys (tab) can be filled in the same table. Now we have all the data needed to calculate the coverage and can use the formulas in the table below.

tag	toilets
tab	toilets

Coverage for girls cg	$cg = \dfrac{tag.q}{g} = \dfrac{\quad\cdot\quad}{\quad} = \quad\%$	If the percentage is higher than 100% e.g. 120% note down 100% as coverage.
Coverage for boys cb	$cb = \dfrac{tab.q}{b} = \dfrac{\quad\cdot\quad}{\quad} = \quad\%$	

These two percentages have to be added up and weighted in relation to the amount of boys and girls in the school. The total coverage becomes than:

Total coverage ct	$ct = \dfrac{cg.g}{g+b} + \dfrac{cb.b}{g+b} = \dfrac{\quad\cdot\quad}{\quad+\quad} + \dfrac{\quad\cdot\quad}{\quad+\quad} = \quad\%$

If this result is below 100% than the school has NO access to improved sanitation.

Access to handwashing facilities.

If above coverage is 100% or more the hand washing facilities we will have to check.

- Is there water available for handwashing? Y/N — If no ⇨ No Access
- Is there soap, ash or sand available for handwashing? Y/N — If no ⇨ No Access
- Are there enough washing points available for the amount of latrines? (not in relation to students)

If we assume that *r* is the max. allowed cubicles per washing point and *wa* is the number of washing points available than is the coverage $= \dfrac{r.wa}{tag+tab} = \dfrac{\quad\cdot\quad}{\quad+\quad} = \quad\%$

If this value is below 100% the school does not have sufficient access to improved sanitation.

* In literature figures vary from 20 to 50. The 25 suggested here can be discussed as it not scientific or experienced based.

** Here the distances vary as well in literature but 50 meters was a commonly used value. This figure is up for discussion.

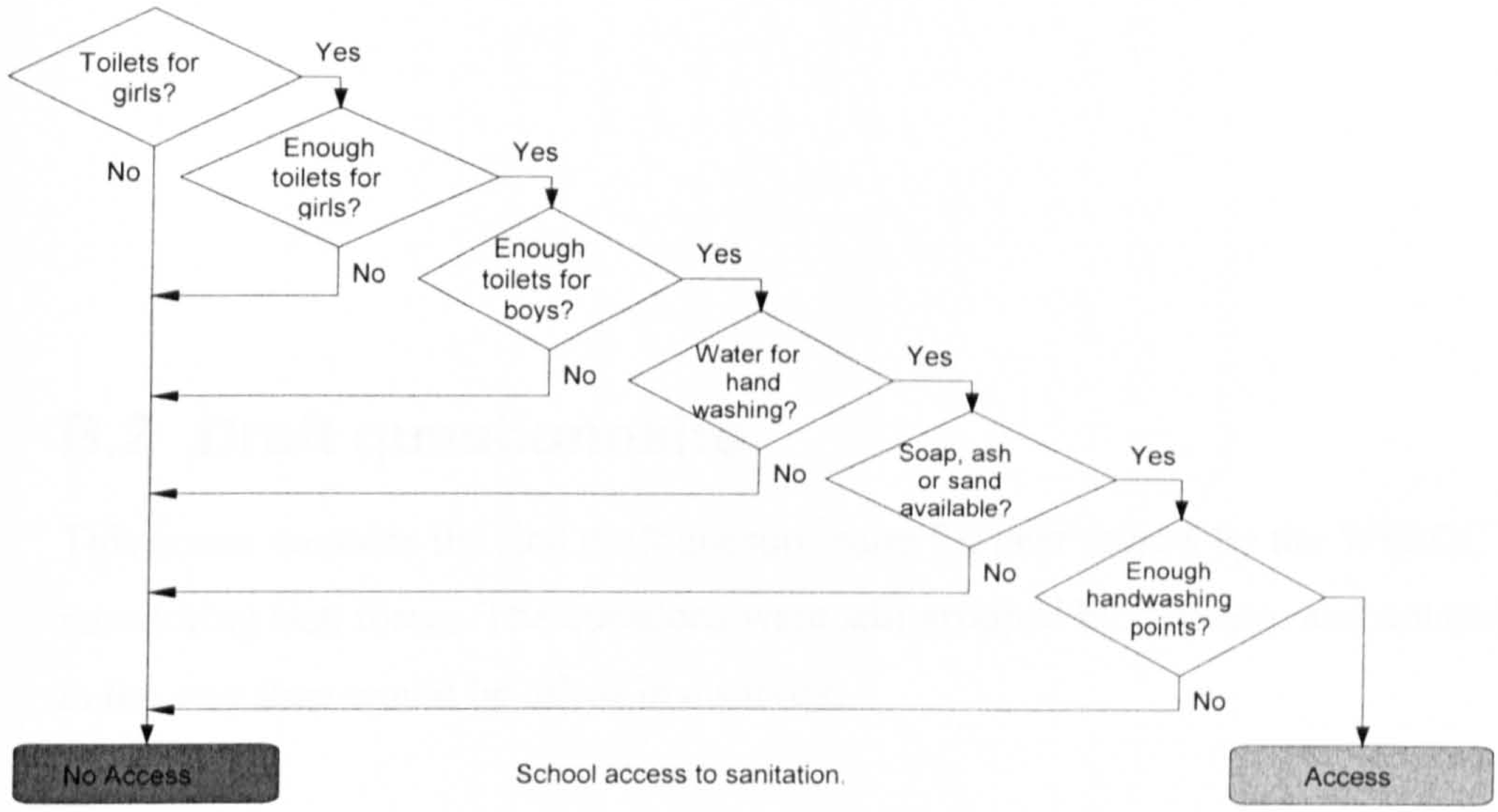

Figure 5: Flowchart of decision model in school sanitation.

B.2 Draft questionnaire

This annex contains the first draft questionnaire for peer review by the WSSCC monitoring task force. The questions were still grouped by indicator and not ordered in the way they would be asked in a survey.

No	QNo	Questions	T*	Answers	
1	A1a	Is there a *place* for hand washing available in the household	o	❑ Yes → **3** ❑ No →**2**	Water and soap [or ash, sand] are present in the HH Unlikely that the HH practises hand washing
2	A1b	Can the household get all the things necessary for hand washing out in ±1 min.? (After being prompted by the interviewer)	d	❑ Yes ❑ No	Water and soap [or ash, sand] are present in the HH Unlikely that the HH practises hand washing
3	A2	Are the hands, in particular the nails, of the interviewee clean?	o	❑ Yes ❑ No	You can notice clean nails! The nails of the interviewee are visibly dirty!
4	A3	What happened to the faeces the last time that your child defecated?	q	❑ Left on the ground ❑ Thrown outside the yard ❑ Thrown in the river ❑ Thrown in the toilet. ❑ Buried. ❑ No small children. ❑ Other (specify)…………………………………	Nothing is done with the faeces after defecation Just scooped and removed from the compound e.g. thrown on a open rubbish dump Thrown in any surface water source like e.g. river, stream, pond Just scooped and disposed of in the toilet (No small children defecating in our yard/house)
5	A4	Are there children (human) and/or animal faeces in and around the HH area?	o	❑ Yes ❑ No	
6	A5	What does the household use as a drawing mechanism for drinking water?	q o	❑ Tap ❑ Dedicated container ❑ Ladle ❑ Nothing specific ❑ Other (specify)…………………………………	From piped water or tap on container e.g. cup should not be stored in the container or on the floor Should not be stored on the floor

* Type of data collection, o= **O**bservation, q= **Q**uestion, d= **D**emonstration
→ go to question …

No	QNo	**Questions**	T*	Answers
7	B1	Ask the interviewee to demonstrate hand washing as done after defecation	d	
8	B1a	Did the collection of handwashing items take less than 1 min.? (This includes fetching things like water, soap, ash or sand.)	d	❑ Yes ❑ No
9	B1b	Is soap, ash or sand used for washing?	d	❑ Yes ❑ No
10	B1c	Were both hands used together? (In the case of a person rubbing only one hand mark NO!)	d	❑ Yes ❑ No
11	B1d	Are both hands rubbed at least three times against each other?	d	❑ Yes ❑ No
12	B1e	Is at least one cup of water poured on hands for rinsing? (If hands are rinsed in a container and water is NOT thrown away, answer NO!)	d	❑ Yes ❑ No
13	C1	Does your household/family use a toilet?	q	❑ Yes — household claims to use toilet ❑ No — Household practice open defecation
14	C2	Is the toilet your household uses	q	❑ Private — used only by your family ❑ Shared — used by more families but they are known to you; ❑ Public — available for use by anybody.
15	C3	Does the toilet show signs of regular use and good access? (If a key had to be found or people needed more time than just the time to walk to the toilet, mark "no")	o	❑ Yes — It is being used regularly ❑ No — It is not being used or is difficult to access
16	C4	Is the toilet clean from excreta around the drop hole/closet?	o	❑ Yes — It is clean ❑ No — It is not clean
17	C5	What type of latrine is used?	o	❑ Bucket or service latrine — To be emptied regularly and transported for disposal ❑ Overhung latrine — Latrine built over river or pond ❑ Open pit latrine — Not covered and no clear drop hole that can be covered ❑ Pit latrine with floor — Is covered with a floor and has a clear drop hole ❑ Flush toilet — Water from a cistern or poured is needed to flush the toilet ❑ Other (specify)..
18	C6	Are there any signs of discharge of effluent to (open drains) or surface water?	o	❑ Yes — Effluent is discharged in open drain or water source ❑ No — No signs of discharge

* Type of data collection, o = **O**bservation, q= **Q**uestion, d= **D**emonstration
➔ Go to question …

No	QNo	Questions	T*	Answers
19	D1	Do you use different sources for drinking and non-drinking (e.g. washing) water? (Exclude water for irrigation, livestock or other non-domestic uses as non drinking water!)	q	❑ Yes — Our water for drinking is different than for washing ❑ No — Our water for drinking and washing is the same
20	D2	How many minutes did it take to collect <u>(non)-drinking</u> water last time you went? ➢ (Return trip, going and back!) ➢ (Non-drinking water is the water you use for washing!)	q	…………………..min.
21	D3	Source of water usually used for drinking? (This is the last question of the questionaire unless specified otherwise).	q	❑ Surface water — Rivers, canals, lakes, ponds, ground based rain catchment ❑ Rainwater — House roof based rain water catchment. (not ground based) ❑ Ground water **➔22,23** Boreholes, wells, hand-dug wells, infiltration wells ❑ Piped water**➔24**Tap at home, in the yard, public tap-stand, neighbour's tap ❑ Spring water **➔23** — Spring, artesian well etc. ❑ Tanker/vendor — Water sold at or close to the house by <u>mobile</u> vendor ❑ Bottled water — Factory bottled drinking water ❑ Other (specify)………………………………………………………………
22	D4	Do you use any kind of pump (manual or motorised) to get your water?	q	❑ Yes ❑ No
23	D5	Has the source you use any cemented wall or platform (cover) as protection? (LAST QUESTION)	q	❑ Yes ❑ No ❑ Don't know
24	D6	For how many hours during daytime-per day is water <u>NOT</u> available? (LAST QUESTION)	q	…………………..min ❑ Always water — E.g. any time I turn on the tap there is water!

[*] Type of data collection, o = **O**bservation, q= **Q**uestion, d= **D**emonstration
➔ Go to question …

Schoolchildren Sanitation knowledge

Question A1 **Are you a boy or a girl?**	
X	Boy
O	Girl
---	Don't know

Question B2 **What is best, washing your hands before or after eating?**	
X	Before
O	After
---	Don't know

Question C3 **Which water is healthier for drinking; from the river or from the hand-pump?**	
X	River, pond, ground level rainwater catchment…
O	Hand-pump, mechanical pump, roof rainwater catchmet, (Piped water?)
---	Don't know

Question D4 **D) Is it better for your health, to wash hands before or after going to the toilet?**	
X	Before
O	After
---	Don't know

Answer sheet

Question	Answer
A1	
B2	
C3	
D4	
E5	
F6	
G7	
H8	

Question E5 **Can you get sick/unwell from flies on your food?**	
X	No
O	Yes
---	Don't know

Question F6 **Why should you wash your hands with soap (ash, sand)?**	
X	Because you mum/ dad tells you.
O	Because it is good for your health.
---	Don't know

Question G7 **The best way of washing hands after going to the toilet is with the hands apart (e.g. only the left hand) or with both hands together?**	
X	Apart, e.g. One hand only
O	Together
---	Don't know

Question H8 **What should be done with the excreta of all young children such as your little brother's or sister's?**	
X	Don't touch it and every body should leave it where it is?
O	Somebody has to put in a toilet or bury it?
---	Don't know

Access to sanitation and handwashing facilities

No	Questions	Answers
1	How many schoolgirls are having recreation at the same time. (***g***) This normally the amount of REGISTERED schoolgirls if no special measure are taken to reduce this.	……………………girls (***g***).
2	How many schoolboys are having recreation at the same time. (***b***) This normally the amount of REGISTERED schoolboys if no special measure are taken to reduce this.	……………………boys (***b***).
3	Maximum amount of schoolchildren per cubicle, according to national standard. (***q***)	……………………Pers./Cubicle (***q***). (If no standards take 25 Pers/Cubicle)
4	The number of improved toilets* available to girls (***tag***). Schoolgirls need separate building for their toilets. See National standards. If this is not the case ***tag***=*0*	……………………toilets available for girls (***tag***).
5	The number of improved toilets* available to boys (***tab***). Schoolboys need separate building for their toilets. See National standards. If this is not the case ***tab***=*0*	……………………toilets available for girls (***tab***).
6	Is there water available for handwashing?	❑ Yes ❑ No
7	Is there soap, ash or sand available for handwashing?	❑ Yes ❑ No
8	What is the number of washing points available (***wa***)	……………………washing points available (***wa***).
9	Maximum amount of cubicles allowed per washing point available, according to national standard. (***r***)	……………………cubicles allowed per washing point (***wa***). Is no standard available use 4 cubicles/ washing point.

* Cubicles for boys or girls are only counted if they:
- have a superstructure that gives enough privacy (e.g. proper door, walls etc.).
- are a pit latrine with floor and a small drop hole or.
- are flush latrine and water for flushing is available.
- The toilet is clean around the drop hole/closet.
- They are no further than ±50 meters/paces away from the outside of the building.

WSH Indicators for EPH II

Deadline: **31 May 2002**

Deliverables:

- **Draft list of indicators** to measure Vision 21 targets (ready for peer review.)
    - Combined proxy indicators for the 3 Vision 21 targets at household level
    - Resulting in binomial value per Household
    - List of assumptions
- **Draft questionnaire**

(This document)

- ***Discussion paper*** *highlighting rationale and assumptions*
    - Outline to approaches in field verification of the
    - assumptions and
    - testing of the questionnaire.

Comments or suggestion on this document or issues relating to it are welcomed

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<u>List of abbreviations:</u>

BSU	Basic Sampling Unit, the unit from or for which the data is collected.
CMD	Camp Dresser & McKee International Inc.
EHP	USAID's Environmental Health Project
GA2000	Global Water Supply and Sanitation Assessment 2000. (WHO and UNICEF 2000).
HH	Households
IAP	Iguaçu action plan
JMP	Joint Monitoring Programme of UNICEF and WHO
UNICEF	United Nations International Children Emergency Fund
USAID	United States Agency for International Development
V21	Vision 21
WHO	World Health Organisation
WSSCC	Water Supply and sanitation collaborative council.

Measuring access to improved services and their use.

1 Introduction

This discussion paper on water, sanitation and hygiene practice indicators is a contribution towards the Iguaçu action plan (IAP) objective to improve the validity and reliability of existing water, sanitation and hygiene indicators and develop new indicators and methods where necessary. This discussion paper is based on an issues paper written by Prof. Cairncross, and includes the feedback received from UNICEF, WHO, IRC and others. Most of the work in this paper was supported by USAID's EHP II project apart from the work on indicators for sanitation in schools which is part of a bigger project proposal put to the WSSCC.

Work was done at the London School of Hygiene and Tropical Medicine. It includes:

- Draft list of indicators for peer review
- Draft questionnaire
- Discussion paper on the indicators including
- Approaches for field testing the indicators

This paper does not contain any information on sampling or any other statistical procedures to test the validity of the indicators.

2 General

2.1 *Targets of Vision 21*

Vision 21 has 6 targets as illustrated in Table 1 (annex 1) and briefly discussed below. Their achievement is planned by the year 2025. Intermediate targets have been set out for the year 2015 as shown below. To enable progress being measured on these targets, baseline information must be available. Some of this baseline information is available in the form of the 'Global Water Supply and Sanitation Assessment Report Year 2000' (WHO and UNICEF 2000).

2.1.1 Target 1

	Vision suggested targets for 2015	for 2025
1	Universal public awareness of hygiene	Good hygiene practices universally applied

The above are abstract ideals rather than targets. Would it not be better to measure the same 'application of good hygiene practices' or 'awareness of hygiene' during both periods to enable comparison? As it is practice rather than awareness that is an engine for change and to obtain a more quantitative objective for 2015, the following is suggested as a working definition.

1	*Halve the percentage of people not applying good hygiene practices.*	Good hygiene practices universally applied

To measure this there is a need for baseline data which are not available.

Another problem in achieving these targets is the definition of 'good hygiene practices'. For the purpose of Vision 21 we would suggest to define good hygiene practice by:

Day to day application of practices and habits reducing risk of faecal-oral transmission of pathogens.

This definition would focus on faecal-oral transmission as the biggest cause of hygiene-related morbidity and mortality (WHO 1992) largely preventable through access to water, adequate sanitation and hygiene practices.

Measuring universal application of good hygiene practices is difficult to do. In particular if it means 100% application. For that reason we suggest that for working purposes "universal" is defined as *90% ±10% (abs. %) at a 95% confidence interval* of households applying good hygiene practice, which would make it statistically more useful as a reference.

2.1.2 Target 2

	Vision suggested targets for 2015	for 2025
2	Percentage of people who lack *adequate* sanitation halved	*Adequate* sanitation for everyone

In its 'Global water supply and sanitation assessment 2000' WHO / UNICEF joint monitoring programme (JMP) is no longer reporting on '*safe*' drinking water and '*adequate*' sanitation. Instead, '*improved*' water and sanitation technology types are now reported. This change in terminology reflects both the past misrepresentation, and the future uncertainty, in judging and defining services as 'safe' in terms of human health (Hunt 2001). For that reason we would suggest that the same terminology be used in Vision 21 targets. It is also the terminology used in the rest of this document.

2	Percentage of people who lack *improved* sanitation halved	*Improved* sanitation for everyone

Sanitation here is seen in its narrowest definition as euphemism for 'human excreta disposal' and will be regarded as such in the rest of the document.
If access for everyone means 100% access than this will be difficult to measure and to achieve as mentioned above. For statistical reason we will define 'everyone' as *90% ±10% (abs. %) at a 95% confidence interval* of households having access to improved sanitation.

2.1.3 Target 3

	Vision suggested targets for 2015	for 2025
3	Percentages of people who lack *safe* water halved	*Safe* water for everyone

Here as well we would suggest the JMP terminology of '*improved* instead of '*safe*' for the same reasons as mentioned before. This would make the targets as follows:

3	Percentages of people who lack *improved* water halved	*Improved* water for everyone

Discussion of what *improved* means is still an issue. In this document 'Having improved water means:
- Consume drinking water with a potentially reduced pathogenic load and
- Obtain enough non-drinking water for basic hygiene purposes.

2.1.4 Target 4

	Vision suggested targets for 2015	for 2025
4	80% of children educated about hygiene	All primary school children educated about hygiene.

Under this target we will understand that primary school children can prove a basic understanding of hygiene. If children can demonstrate their understanding of hygiene practices this will prove that they have been taught this, most likely at school, and that it was taught properly. It is the knowledge acquired that might improve their behaviour, not the knowledge taught.

2.1.5 Target 5

	Vision suggested targets for 2015
5	All schools equipped with facilities for sanitation and hand-washing

To make this into one clear target it will considered as 'School having access to adequate excreta disposal facilities, with handwashing facilities included into this definition of 'having access'!

2.1.6 Target 6

	Vision suggested targets for 2015	for 2025
6	Diarrhoeal disease incidence reduced by 50% (indicator considered for health sector)	Diarrhoeal disease incidence reduced by 80%

This is considered a medical objective, progress to which must be assessed using very different method, and so will not be used further in this document.

2.1.7 Optional basic outcomes

For many years projects have been initiated providing water to household without adequate provision for **wastewater disposal**. If wastewater can not be properly disposed of, it might reduce the household consumption of water for hygiene purposes or lead to other health problems. To avoid this it might be worth considering another outcome (not target) to be included in the survey indicating that 'The household has **adequate provision for wastewater disposal**.
A further optional extra outcome of the survey might be **drinking water in schools for the students.**

2.2 Basic sampling unit

For Vision 21 targets 1-3 (see annex 1) the basic sampling unit suggested is the household. Research findings suggest that as neighbourhood levels of faecal contamination improve, the conditions and practices within households become more important. This means a move away from the traditional, engineering approach to public health {Cairncross, 1996 #12}. It brings the focus towards *private* health at household level. The concept of the *domestic domain* encompasses the decisions and actions taken at household level and their relation to environmental health, and is distinguished from the public domain in which the intervention of public authority is required to prevent disease transmission. This model acknowledges the importance of household practices and behaviour. A household-centred approach to environmental health has been advocated {DFID, 1998 #5}.

Households are universal and relatively easy to identify. This makes them suitable to be used as basic sampling unit (BSU). However choosing the household as a basic sample unit makes the outcome a percentage in terms of households. All distinction between various types of household, such as man alone or woman and children, will be lost for analysis. This means also that gender issues will be lost. The term "household" may be interpreted according to local conditions; however a convenient definition could be "those whose food is prepared by the same person".(Bennett S. et al., 1991). This definition might still pose a problem for the increasing amount of single (mostly man-only) households in urban slums. It might be necessary to verify if the data obtained at household level is representative of the population before inference is made from the obtained results.

Despite the household being the suggested basic sample unit there might be situations were the number of water sources is limited. In that case it would be possible for the interviewer to visit the sources which were mentioned during the survey. This would allow verifying indicators such as the level of source protection, the distance between household and source, or other issues which otherwise have to be assumed. In those cases, collecting additional information at water SOURCE could be considered to improve the survey accuracy.

The problem is that sampling households leaves aspects such as sanitation around public places out of the picture. Including it in the same survey would be difficult as the evaluation is different and a weighting factor to include it in the same statistics would be difficult to calibrate.

For Vision 21's target 4 the sample unit is school children while for target 5 it is the school as a whole that represents the BSU.

2.3 Representation of the basic sampling unit

Who in the household will give the information that is most representative for the household? Women have been traditionally at the 'practical' day-to-day centre of the household. They are usually involved in the collection of water, preparing the food and taking care of the children and cleanliness in and around the dwelling. So they seem to be the most suitable candidates to interview. This assumes that there is in most cases a 'normal' family constitution. In some cultures, interviewing women might not be straightforward. With so many responsibilities, women might not always be available to give information which might increase the non-response rate in the samples. It is suggested that the person involved in the cooking, cleaning and collecting of water for the household is the person to interview. It is assumed that this person will generally be the 'woman of the house'

2.4 Outcomes

"The monitoring or surveying for which the JMP was established (with a mandate from the UN Secretary General), and which the WSSCC was mandated at Iguaçu to promote, is principally "summative". Its aim is to measure a small number of quantitative indicators to determine whether targets were being achieved (Cairncross 2001). Summative data only are concerned with characterisation of a situation while formative information is more analytic about the situation, seeking a diagnosis of problems needing resolutions.

If the household is acceptable as the BSU, the outcome of the survey is a binomial value by household for each target. These will indicate for example if the household has or has not access to water. This means that all indicators we assume important and relevant for each target have to be combined until they reach a yes or a no value.

Targets 1-3 needs outcomes for each household that can lead to the conclusion that the household has:

1 *Yes/No good hygiene practices*; meaning that the behaviour of the household is such that it reduces the risk of pathogenic transmission.
2 *Yes/No access to adequate sanitation*; meaning that excreta is disposed of in such a way that it reduces the risk of faecal-oral transmission to its users and the environment.
3 *Yes/No access to improved water supply*; meaning that they have access to sufficient drinking water of acceptable quality as well as sufficient quantity of water for hygiene purposes.

Targets for school sanitation say that:

4 *Yes/No school child knows about hygiene* meaning that primary school children have most likely being taught about hygiene at school, but more important have gained a basic understanding on hygiene practices.
5 *Yes/No school is equipped with facilities for sanitation and hand-washing* meaning that primary schools have enough improved excreta disposal and handwashing facilities for students and staff.

2.5 Data collection

In public health the use of sophisticated research designs and statistical techniques is only as strong as the data that is used for these analyses. The quality of the data depends on the quality of the sampling and measures used in their collection. It is the collection of accurate data that is the foundation for all other scientific and non-scientific data analyses.
There are many ways of systematic data collection. For hygiene related issues, summative information is generally collected trough questionnaires, structured observations and demonstrations on request. Systematic data collection by using questionnaires has some powerful advantages over less structured approaches as well as some limitations.

Advantages:
- Efficiency: simple and cheap to administer;
- Consistency, comparability, generalisation: Standardised formats ensure all respondents are asked the same question
- Summary and analysis: it provides quantitative data that can be quickly summarised.
- Scientific rigour: questionnaires can evaluated for reliability, validity and responsiveness

Limitations:
- Limited depth: cannot generally provide an in-depth view;
- Inflexibility: structured, standardised format is constraining;
- Cost: significant time and resources are required to test and develop questionnaires;
- Error and bias: in questionnaire design and administration as well as response rates.

Structured observations have some advantages and limitations.

Advantages:
- Information on the physical environment and human behaviour can be recorded
- Observer can 'see' what the untrained eye can miss, as he/she is focussing on the issue.
- Information can be collected on people that cannot take part in interviews, such as babies.
- The information can be checked against other sources, so claims of behaviours in interviews can be checked with observed behaviours

Limitations:
- It is not always possible because of social constraints or the behaviour one wants to observe is rare or irregular.
- Behaviour may change due to the presence of the observer.
- Behaviours can be correctly recorded but misinterpreted through the observer.
- It is time consuming and therefore expensive

Demonstrations

Advantages:
- Can be prompted by an interviewer.

Limitations:
- Can be time consuming.
- Result might not be representative for day-to-day practice

In our 'summative' survey, open-ended questions would supply us with far more information than needed and would make it more difficult to standardise the outcomes. It would also need more training of the staff doing the interviews. For these reasons open-ended questions will not be considered. As mentioned above, the biggest disadvantage of structured observations is the time needed to make the observations. For that reason we suggest that observations be restricted to spot-observations by the interviewer during the interview. The observations, behaviours or physical characteristics chosen for the survey are only useful if there a high probability of observing them during the interview. Spot-checks in the case of V21 assessments will observe signs of behaviour rather than the behaviour itself, because it is unlikely that the behaviour will occur during the time the interviewer is present. An interviewer can always prompt an interviewee for a demonstration if needed.

2.5.1 Considerations on data collection

For the three first V21 targets the BSU is the household and all information will have to be available at the household level. This means that questions about matters such as lining of pits or treatment of tap water are not suitable questions as the kind of information they seek will not always be known at household level.
Several investigations have used observational data but little work has been performed to confirm their validity and repeatability (Boot and Cairncross 1993; Ruel and Arimond 2002). Additional research is

needed to assess the validity, reactivity and repeatability of hygiene indicators and composite indices derived from spot-checks in various cultures (Kolsky and Blumenthal 1995; Ruel and Arimond 2002) To make the whole survey widely applicable, the data collected should be as universally possible. Also the way the data is collected will determine how widely applicable the method is. Cross-cultural adaptation and testing of questionnaires requires significant time and resources. One way of overcoming this problem is to work with interviewers who specify the interpretation of the questions in the light of local circumstances, and make appropriate observations. This human interface for collecting data might be a good way of increasing the likelihood that the method can be used in most contexts. It is therefore suggested that the data collection in the survey will be based on:

- interviewer-administered questionnaires in combination with
- interviewer rated spot observations
- demonstrations on interviewers request.

The locally selected interviewers will be trained to ensure they obtain valid responses, and will be of the gender that will most likely deliver the right results if gender is considered to be an issue.

2.5.2 Consideration on the questions and observations

Questions and in particular spot-observations have also the advantage that limited time is needed to collect information. This would allow adapting questions and observations for different cultures and situations to obtain comparable results. To allow such adaptation it is important that each question clearly states:

- **Why** the question is asked;
- What will be **concluded** from the answer;
- What were the **assumptions** leading to the conclusions.
- **Remarks** e.g. what to do if the assumption prove wrong in a particular survey?

The combination of questions and observations also allows triangulation to check the validity of outcomes and assumptions. Decision on the relation between the different outcomes has to be taken before administering the questionnaire and checking for relationships.

Below are two examples of what could be questions, answers and assumptions in regard to the access to water to demonstrate this.

Question/Observation
How many minutes did it take to collect (non)-drinking water last time you went? (Return trip, going and back! Non-drinking water is the water you use for washing!) **…… min** To go and come back from the water source queuing included!

Conclusion
If less or equal to 30 min the household has access if the source is considered an improved water source.
Rationale/assumptions
It has been shown (Cairncross and Feachem 1993) that if between 3 to 30 min time is needed (round trip) for water collection the amount of water collected varies little with the distance. If more time is needed the of collected water amount drops. The time we want to obtain with this question is the time spent going and coming back from the source plus the time spent queuing and pumping. What we want to exclude is the time for other activities like e.g. socialising unless they were done during the queuing. The assumptions are: • People are good in estimating time. • Difference in altitude between household and source or difficult paths will partially be represented by the extra time needed to collect the water; • Effort to abstract water like e.g. pumping will be represented in the water collection time.
Remarks
During the preparation for the survey interviewers will have to be trained to obtain the correct time.

Question/Observation
Do you use any kind of pump (manual or motorised) to get your water?
❑ YES ❑ NO

Conclusion
If **yes** the source is considered a protected and improved water source.
Rationale/assumptions
In this question it is assumed that if the water is obtained trough pumping it is most likely a source that is properly protected. It assumes as well that not many unprotected sources have pumps. An assumption that needs verifying, however experience suggests that it is general true. (Discussion on verifying might be needed.)
Remarks
Collecting information on the way the source is protected can prove difficult because the household may not know, and the protection may not be visible.

2.6 Bias in data collection

Selection bias

This type of bias is related to the sampling method, which is outside the context of this document.

Information bias:

observation (interviewer) bias, can be reduced by selecting unambiguous questions with clear answers and good training of interviewers to standardise understanding and observations.

Interviewee bias can be reduced by using spot-observations for questions that will be stigmatised or otherwise sensitive to interviewee bias.

Recall bias is not a problem, because information needs from past events is not required.

3 Indicators

3.1 General

The assumption behind the survey is that health in the community can be improved through access to water and sanitation as well as the application of hygiene practices. We want to know how far populations have access to or practise what we think will be beneficial for their well being. However these values are relatively abstract and difficult to measure. This has been partially solved by the development of indicators.

To take an analogy from bacteriology, it is practically impossible to measure pathogenic concentrations of the cholera vibrio, Salmonella typhi, and every other currently known disease-causing organism in drinking water or in food on a regular basis. It has, however, become relatively straightforward to measure the indicator organism *E. coli*, and this indicator has been widely successful in advancing the objective of "safe drinking water" to promote the value of "Health for All." (Kolsky and Butler 2002).

Performance indicators are defined in this paper as practically useful surrogates for the direct measurement of performance. Most standards are based on indicators, because they can be measured reasonably easily, rather than the performance itself.

Indicators are by definition, "an indication" of status or process rather than the measurement of the status or process itself. Indicators are in this way inherently open to debate precisely because they are imperfect for the surrogates they 'indicate'. The question continually asked during the whole process of choosing indicators is wether the indicator reflects accurately enough the critical aspect of the performance.

Ultimately, we are concerned with indicators because we seek a practical way to obtain relevant data about performance on which to base decisions.

As argued in paragraph 2.5 on 'Data collection' (page 422) only the following three ways of collecting data will be considered in the rest of this paper:

- Interviewer administered questions with the exclusion of open-ended questions;
- Interviewer's spot-observation during the interview;
- Interviewer-initiated demonstration by the interviewee of hygiene practices.

The indicators that have been considered for the questionnaire have been marked with a "◎"at the end of the headings of the paragraphs which discuss them.

3.2 Multiple Indicators for assessing hygiene practices

With these indicators we want to measure hygiene practice as it is applied on a day-to-day basis and not knowledge at the household level. Only practice (whether based on knowledge or not) will have a positive impact on the household. The indicators will take into consideration only the situation as it is at the time of the interview. The results from the survey are purely summative and not formative. The data will be collected through interviewer administered questions and interviewer's spot-observations. The concentration around spot-observations is to avoid interviewee bias by not giving information in relation to what the household think they should answer rather than what they practice. In many publications, desirable practices were reported but not observed more times than they were observed but not reported (Curtis, Cousens et al. 1993; Manun'Ebo, Cousens et al. 1997; Gorter, Sandiford et al. 1998). Moreover it is generally accepted that there is a strong recall bias on a lot of hygiene related questions. Even within a 24h recall period, results of interviews can be unreliable when compared to observations (Stanton, Clemens et al. 1987).

WHO identified three key messages in regard to water sanitation and hygiene practices of which the two below are relevant in this part of the document (WHO 1992):

- 'Handwashing after defecation, after handling babies faeces, before feeding and eating and before preparing food' and
- 'Maintaining drinking water free from faecal contamination, in home and at the source'.

The third one, which relates to proper excreta disposal, will be treated later in this document. The 'hygiene practice' indicators used should be as independent as possible from the access to water and sanitation indicators to avoid, for example, a lack of access to water automatically appearing to have consequences for hygiene behaviour/awareness. Although this is desirable, it is difficult due to the prominent place that water supply and sanitation facilities play in the hygiene practices of the household.

Measuring practice does not imply a guaranteed positive health impact although in public health terms it is expected to be more likely. One of the major problems in assessing the validity of a way of measuring hygiene practices is that there is no 'Gold standard' (Manun'Ebo, Cousens et al. 1997) to

refer to or to compare with. Moreover although the risk factors and transmission pathways of many pathogens are understood their interaction with the everyday environment is less well understood.
Not all observations will be possible so an algorithm is needed to condense the different observations into a single indicator.
For instance 6 observations of which 3 have to be collected and a score calculated from positive versus negative behaviours. In this example it could be min 2/3 or 67% positive behaviours which relates to 2 out of 3 (67%), 3 out of 4 (75%) 4 out 5 (80%) and 4 out of 6 (67%) positive observations.

Indicators should be:

- Representative of general hygiene behaviour.
- Easy to observe (no high education of field workers necessary).
- Not costing much time (easy to observe during a certain time period)
- Unambiguous (limited observer differences)
- Practice of observations likely to happen during interview (thus producing little missing data)
- Observation accessible for field worker (Not requiring access to private parts of the dwelling e.g. kitchen.).

In addition indicators should be:

- As independent of season and context as possible.
- As independent (not related) from each other as possible

Adapted from Gorter, Sandiford et al. (1998)

Evidence from literature on structured observations suggests that the validity, reliability and reactivity of the indicators are context-specific (Ruel and Arimond 2002). Most of these researches are *formative* in the sense that they collect qualitative information to assist diagnosing and analysing a situation. In our case the goal is just to collect *summative* information in which the context dependency can be strongly reduced by proper choice of indicators.

(Boot and Cairncross 1993) Page 35 distinguishes five different domains of hygiene behaviour.

- Disposal of human faeces;
- Use and protection of water sources;
- Personal hygiene
- Food and water hygiene*
- Domestic and environmental hygiene

(Boot and Cairncross 1993)

The first two domains distinguished by Boot and Cairncross being ①human excreta disposal and ②use and protection of water sources are related Targets 3 and 4 of Vision 21 and will be considered later. The three other domains ③ personal hygiene, ④food hygiene and ⑤domestic and environmental hygiene will be considered below to categorise the different potential indicators for assessing hygiene practices.

3.2.1 Personal hygiene

Handwashing

Although anyone will agree that handwashing is an important hygiene practice and useful as an indicator for health behaviour, it is more difficult to assess. Handwashing and faeces disposal were suggested for inclusion in the DHS core questionnaire (Kleinau 2002). The question "when do you wash your hands" (without prompting) was put forward, but nothing about actual handwashing practice. Asking about appropriate times for handwashing during a pre-test in the Dominican Republic, 2 of 3 answers were eliminated because they had no discriminatory power, and the handwashing question was reduced to: "The last time you prepared a meal for your family, before starting did you wash your hands?" (Kleinau 2002). Because most people (>90%) respond positively to this remaining question, its usefulness is questionable. Clear over-reporting on handwashing compared to its occurrence in structured observations is common (Manun'Ebo, Cousens et al. 1997). The underlying issue appears to be how to gather information when it cannot be done in a meaningful way through a single question. It would seem that there is substantial experience of other ways to assess handwashing behaviour, but all require several questions and observations. A good proxy is the observation of a place for handwashing and the presence of water/tap, soap and basin as used by the DHS. The question does not really check whether water is actually available which might be a useful addition. Observing

* Food hygiene is the term most frequently used in the water and sanitation sector, though specialists more often refer to it as food safety (Boot and Cairncross 1993).

a handwashing demonstration on request has been done in other surveys, but it is probably too time consuming for a DHS, unless as part of a WSH module (Kleinau 2002). Different studies have tried to find the right non-leading single question to assess handwashing. E.g.:

- On what occasion do wash your hands?
- On what occasion do you teach your children to wash their hands?
- Do you use soap when you wash hands?
- On what occasion do you use soap to wash your hands?

These attempts have had so far limited success. One of the possible reasons for this limited success could be that people mostly wash their hands for purposes other than hygiene (Zeitlyn 1994). Some research showed that not only the purpose of hand washing varied but compliance changed during the day (Huttly, Lanata et al. 1994). There may be a need for additional operations research to decide the best way of assessing hygiene behaviours like handwashing (Ojajarvi 1980; Kaltenthaler, Waterman et al. 1991; Hoque, Mahalanabis et al. 1995). Assessing hand washing through questions or observations seems to be difficult and for that reason is it not considered here. It will be considered below as a demonstration

System for handwashing ●

One of the more objective ways of assessing the likelihood that handwashing is commonly practised is to check if water and a washing agent like soap, ash or sand is available. This can be done through checking if there is a dedicated place in the household for this purpose. If needed, the interviewer can ask if he/she (the interviewer) can wash his/her hands to provoke a response or ask the interviewee to demonstrate handwashing as if after defecation. Instead of assessing if a dedicated place for handwashing is available, the interviewer could observe whether water and washing agents can be seen when handwashing is demonstrated (within a short period, e.g. 1 minute). In the next paragraph, more attention is given to a handwashing demonstration on request as an alternative to this question. At least one of the two is definitely worth including in the survey.

Handwashing demonstration as an indicator ●

We could replace the question above by a request for a handwashing demonstration and do a more in depth analysis. Before we do this it is important to state why we would measure this. Handwashing is a good barrier against faecal-oral transmission of pathogens. Increase of handwashing will improve health in a household. That is because the purpose of our handwashing is the reduction of pathogenic organisms on our hands. In many parts of the world handwashing is not perceived being related to hygiene or health (Zeitlyn 1994; Hoque, Mahalanabis et al. 1995). One person might use several methods of handwashing during the day, for example: rub the left hand with mud and rinse it with water after defecation; pour water over the right hand before eating; rub hands, arms legs and feet with water before prayer; or wash hands along with other parts of the body with soap in the course of a daily bath (Zeitlyn 1994). This indicates the importance of defining which handwashing practice we want to evaluate. There are indications that in reference to the F-diagram (Figure 1 on page 444) first barrier handwashing is more important than second barrier handwashing (Curtis, Cairncross et al. 2000). This could be explained by the possible different loads of pathogens. For this survey we will refer to handwashing as first barrier handwashing or handwashing after faecal contact.

Knowledge in some unpublished studies (Shordt 2001) showed that knowledge of handwashing practices was more prevalent than successful demonstration. This follows the general trend in many publications that hygiene practices were much better known than practised. (Curtis, Cousens et al. 1993; Manun'Ebo, Cousens et al. 1997; Gorter, Sandiford et al. 1998). Knowledge and practices are clearly two different things.

Four factors determine the efficiency of handwashing (Hoque, Mahalanabis et al. 1995):

- Washing agent;
- Rubbing;
- Rinsing and
- Drying.

It must be said that for such a simple daily activity as handwashing all relation to the reduction of pathogens are not fully understood.

The demonstration will be evaluated as follows:

- Can get all things needed (water, washing agent, basin if needed) within one minute.
- Uses soap or any other washing agent, like ash or sand.
- Uses both hands,
- Rubs hands in at least both directions,
- Uses at least one cup of water for rinsing poured on the hands,
- No prompting by other people.

This demonstration is likely to take more time than the observation mentioned in the previous paragraph. For that reason it will be kept as an alternative to the former indicator.

Cleanliness of the interviewee/mother or caretaker ⊕

If the mother is considered representative of the household, the cleanliness of her hands (e.g. *dirt under the nails)* could be a spot-check proxy indicator for frequent washing of the hands. The assumption being that the mother will be representative of the household in this respect. Her central place in the household will make that non compliance with basic hygiene practices like handwashing will affect the health of household members such as the children she takes care of and the people she cooks for. An alternative is to check if the caretaker of the children has dirty nails.
Other alternatives would be cleanliness of face, hair or clothes but these are more difficult to evaluate as one has to distinguish between aesthetic cleanliness and hygienic cleanliness.
Cleanliness of child's hands (nails), face, clothes could be considered, any association with washing could become unnoticeable within a short time after washing. Cleanliness of nails of the mother or caretaker will be used as an indicator although it could theoretically be a cofounder with the availability of handwashing facilities.

Proper disposal of children's faeces ⊕

This question has been recently asked as part of UNICEF MICS (Henderson 2002). After data analyses by UNICEF in the coming months, it can become clear how useful this question is.
A good and non leading question to collect data could be 'What happened the last time your child defecated?' (Curtis, Cousens et al. 1993). Possible answers could be categorised as follows :

- Leave on the ground.
- Throw outside the yard.
- Throw in the latrine.
- Throw in the river/stream/pond.
- Bury in the yard.

But if access to sanitation is negative this will almost automatically result in this indicator becoming negative? For households with no young children this question will be useless. Still we think it is worthwhile considering the indicator and it will included in the draft questionnaire.

Child uses diapers, underclothes/clean child's bottom.

In a review of seven studies using spot observation (Ruel and Arimond 2002) this was seen as a good indicator for child diarrhoea. As this is strongly related to other hygiene practices it might also be a good indicator for hygiene practice. However it is also noted in the same publication that there could be association with living standards and income of the households. It therefore does not seem to be a suitable indicator and will for that reason not be considered.

Bacteria on finger tips

Although a good indicator, its requirements for enough time and financial resources as well as specialised equipment and skills makes it less appropriate to be used as an indicator in this type of survey. It will not be considered here.

Cleanliness of sanitation facilities

A good indicator for hygiene practice. However it can not be assessed in households which have no access to sanitation facilities. This makes this indicator less appropriate. As it is also proposed for use under heading 3.3 on access to improved sanitation. It will not be used as an indicator for hygiene practices.

Toys or baby bottles on the ground

Only valid if there are kids with toys or bottles. A lot of people without access will have little toys to leave on the ground or alternatives to the ground for toys anyway. It is not considered as a good indicator for our purposes.

3.2.2 Food and water hygiene

It is generally known that faecal contamination of food is far higher than that of water (Boot and Cairncross 1993; Cairncross 1995). Still the focus of attention is directed towards drinking water.

Water consumption

Collecting enough water could be good health behaviour indicator. Relatively little additional water is needed for human consumption; most of the extra water, when consumption increases, will generally be used for cooking, cleaning and other activities. Water consumption will be determined mainly by three factors. Access to water source which is discussed later; the amount of water collected; and the amount of water used for various purposes although evidence suggest it does. There are however some problems with water consumption as indicator. First of all it assumes that all the water is brought to the household. To save energy a lot of people will wash themselves and their clothes close to the water source. Even collecting larger amounts of water does not always imply that is used for hygiene purposes, however evidence suggests it is the case. Practically it is difficult to measure the consumption and moreover it has to be measured in relation to the assumed need. This and other issues make it difficult to use it as a practical indicator. For those reasons it is best not to consider water consumption as an indicator.

Water storage

Covered water storage has also been used in various publications as an indicator for hygiene behaviour. Most of the water pollution often happens in the domestic domain, when drawing water from the storage vessel. So just checking if the water is covered seems to be a limited indicator. Moreover if people are not storing their water this indicator would not be applicable. It seems to be more useful to target the indicator on the way drinking water is drawn within the household as suggested below.

Testing for slime on the inside of the storage container was suggested as an indicator, but there are no real health effects or health behaviours that can be related to slime building up in containers. Moreover it would mean that the interviewer has to check the inside of containers. The way drinking water is drawn for consumption seems to be a more direct indicator. Water storage as such will not be considered.

Suitable water drawing mechanism for drinking water ●

'Suitable' is defined here as: 'A method preventing the user from polluting the water by consuming it'. This can be evaluated by examining the way people take drinking water. If a method is used that enables the user to take water without hands or a potentially 'polluted' container being in contact with the drinking water, this will be achieved. A tap, or a dedicated ladle, which is not stored on the ground, could be suitable solutions. The assumption is that a lot of pollution happens at the household level if the water has to be stored in the household. Although the household will have to show the interviewer how they draw their drinking water, it seems to us a suitable indicator and will be included.

Storage conditions of food

Presence of leftover food, and covering of the food after cooking to protect it from flies has been used in some research as an indicator. There are some relations between health and the way prepared and unprepared food is stored (Molbak, Hojlyng et al. 1989). However such an indicator could only be useful between the time the food is cooked and the leftovers being eaten. The small time frame in which this might be observed makes this indicator less useful to the questionnaire.

Cleanliness of dishes and utensils

Although this seems at first to be a good indicator, it is not always easy to evaluate. First of all there is the problem of privacy. Dishes and utensils will often be in the cooking part of the household, which is not always easy to access by the interviewer to make observations. Moreover the inspection can only be done visually which makes it dependent on the type of food eaten. The way dishes are stored could be considered but even if they are stored on the ground they might be rinsed before use. If this indicator were assessed just after a meal, it would be difficult to make a correct assessment. As we are not convinced that this is a reliable indicator for spot-observation it will not be considered further on.

3.2.3 Domestic and environmental hygiene

Cleanliness of floor and compound surfaces

The problem with assessments of the floor is that it is not always possible to have access to the house. This is not important if we evaluate both, compound and floor. If either show no sign of cleanliness (e.g. garbage not organised in heaps or absent or, worse, there are faeces visible of any origin) the indicator will be negative.

If the compounds the household is using is a shared compound and there is no clear ownership of a relevant part of the compound the whole compound will be evaluated as a whole. This will reflect more the behaviour of the whole compound community rather than the household. In reality it is more likely that despite the effort of some individuals the compound will not be clean. If there are children in the household, particular attention should be given to the place where children play. Cleanliness is still too vague as a description for a useful indicator. The indicator below is more useful and general cleanliness of floor and compound surfaces will not be considered as an indicator.

Area in and around the household free of children's (human) and animals' faeces

This seems to be an often-used parameter. As it is sometimes difficult to distinguish between children's and animals' faeces, both will be considered. This means that even households without children can be marked on this indicator. The problem is that it is focused more towards low income housing in tropical climates. As this is a relatively subjective observation, interviewers have to be well trained to make observation as standardised as possible. This is discussed below in paragraph 7 'Training of interviewers' on page 443. This indicator is considered a useful indicator.

Waste disposal

Waste disposal has been shown to relate to health. It also shows the willingness of the household to live in a clean environment and is in that way related to the above two indicators which are more suitable for the purposes of the survey methodology. Waste disposal is not always under the control of the household. For that reason waste disposal will not be considered as an indicator.

Flies and other vectors.

The presence of flies in particular in the cooking area, will have a impact on health (Boot and Cairncross 1993). Having a behaviour that prevents flies from having access to utensils will have a positive impact on the health of the household. However the presence of flies is not considered a good indicator. For vector control to effective it has to be done on a larger scale than the household. So the result of the observation might not be so much a result of the individual household's behaviour as we would like it to be. Moreover, the presence of flies can be seasonal. For those reasons we consider the presence of flies and other vectors as a poor indicator for hygiene behaviour.

Animals loose inside the house or the compound.

There are many open questions and much conflicting information about the role of animals in the transmission of water and sanitation related diseases (Boot and Cairncross 1993). There are studies showing a correlation between keeping animals in the house and increased risk of diarrhoea (Pickering, Hayes et al. 1986; Molbak, Aaby et al. 1994; Molbak, Jensen et al. 1997; Westaway and Viljoen 2000), although some studies surprisingly found that animals in the house was assiated with lower diarrhoea rates (Huttly et al. 1987 in Boot and Cairncross 1993). There is no indicator foreseen in the survey for the moment but this is still open to discussion.

3.3 Indicators for access to improved sanitation

3.3.1 Definition of improved sanitation

In identifying key messages in regards to water sanitation and hygiene practices WHO concluded that among three key messages was '*Safer disposal of human excreta, particularly the faeces of young children and babies, and of people with diarrhoea*' (WHO 1992).
In the Global Assessment (WHO and UNICEF 2000) an excreta disposal system is *'improved'* when:

- It is private or shared but NOT public and if;
- It hygienically separates human excreta from human contact.

This results already in two indicators, ①use of the latrine, (private, shared and public) and ②proper technology.

Kind of use of the latrine

Through questions and confirmed by observation it should be possible to determine if the latrine is *private*, *shared* or *public*. Households have been known to falsely claim ownership of a latrine. Latrines may exist, but not be regularly used or they may be in use (e.g. by a landlord) but not accessible to all members of the household. It might also be possible that adolescents and adults use them only because of privacy, which is not considered necessary for small children who might defecate in the open. So it is considered more useful to ask were the child (if there is any) last used the toilet and if that toilet is:

- *Private*: Meaning it is only used by the household interviewed and everybody in the household who has the autonomy to go to the toilet has access, e.g. also children have the key if needed.
- *Shared*: Meaning that the use is restricted to some neighbouring households of which everybody in these households has access to the toilet.
- *Public*: Any person can use the latrine with no restriction to a known set of people.

In the Global Assessment report (WHO and UNICEF 2000), shared latrines were considered an '*improved* form of sanitation'. This was due do the use of existing databases in which it was not always possible to differentiate between shared and private latrines. According to the Joint Monitoring Program (JMP) (Henderson 2002) shared latrines should not be considered improved. This is because of the risk that shared latrines are more likely to be less hygienic, but also because safe use, especially in the night for women and children, will be more problematic.
We would restrict the definition of improved sanitation for households to private toilets and exclude shared toilets as being 'improved' sanitation. This is definitely an indicator to include in the base survey.

Type of technology used

The different technologies used for latrines all have their advantages and disadvantages. The only thing concerning us in our summative survey is whether the technology 'hygienically separates human excreta from human contact' (WHO and UNICEF 2000). We would suggest to add to this 'until it loses its pathogenic load'. As the data is collected on the household level the different ways of identifying the different technologies must be possible by simple observation and questions. This is because the interviewee and sometimes the interviewer may not be aware of the wide rage of different excreta disposal technologies.
Water-seal present
These latrines tend to be flush, poor-flush and aqua privies. They usually connect to a septic tank and/or to a sewer network. They are an improved form of sanitation if there is no proof of effluent visible or discharging into surface water and people have convenient access to water for flushing.
Bucket or 'service' latrine
Faeces in bucket or "service" latrines have to be collected regularly. It is assumed that this is done by hand and transport happens over public roads. All this means that the technology does not 'hygienically separate human excreta from human contact'
Overhung latrines
Latrines built over surface water sources such as lakes and rivers or not considered 'improved' sanitation because they pollute surface waters and put potential users of the water at risk. Installed over a river they would put at risk all people using water downstream.
Pit latrines
Are only an improved form of sanitation if they have a floor and the drop hole is kept clean. Others (e.g. open and generally shallow pits) are considered 'not improve'. They are unlikely to be hygienic and are rarely used by young children because of the danger or fear of falling in.

If the toilet technologies above are considered 'improved' we will assume that:

- The technology is appropriate for the anal cleansing material used;
- Anal cleansing material is properly disposed.

Type of desludging or pit emptying technology used.

Even if an on-site system works properly, there will come a time when it will need desludging or emptying. In contrast with bucket latrines the interval are bigger and the excreta has over time evolved to a lower pathogenic load than if it would have been fresh like in twin pit latrines. However if there is a congregation of households there will always be one or another household in need of emptying its toilet. This regular emptying and transport of faecal matter might pose a risk. Some areas can not be accessed with safe mechanical pumps like the 'VacuTug' and in some communities it is seasonal flooding that will allow regeneration of places in pit latrine but with high health risks during the flooding. Although it is worth taking into consideration it is not seen as an easy indicator for the base survey.

Handwashing facilities near toilet.

Handwashing after defecation is an integral part of the process to separate human excreta from human contact. Handwashing after defecation may be more important than handwashing before food preparation and eating because it controls spreading of faecal pathogens(Curtis, Cairncross et al. 2000). It is however a hygiene behaviour and we would keep it as an indicator for hygiene practices rather than sanitation. Including handwashing as 'condition sine qua non' would make the indicator more an indicator of proper use of sanitation facility in terms of hygiene practice, and less of an indicator of presence of appropriate hardware to dispose of human excreta. We suggest that handwashing be excluded the 'access to sanitation indicators' for the Vision 21 targets but believe it would be a useful optional indicator to assess hygiene practices.

Groundwater pollution.

Some types of latrines might contribute to groundwater pollution. While pathogenic load is unlikely to be an issue unless the aquifer is high, chemical pollution might become an issue in the future (Banks, Karnachuk et al. 2002). It is however generally accepted that the benefits of on-site sanitation will outweigh in most cases the risk of ground water pollution. Moreover, off-site water supply is a cheaper solution to the problem than off-site excreta disposal system. As an indicator it is not useful to take it into considerations for the purposes of the survey.

3.3.2 Definition of access

Distance to the latrine.

Access is more difficult to define. One aspect of access is the time it takes to get to the latrine. For that reason a rough estimate of the distance would be needed. The problem would be where to put the cut-off distance, as there is no evidence base for the decision. We would suggest putting it at ±50m or ±50 paces as it is not a critical measure. It is however important that the same distance is used for areas that will be compared and that interviewers should be trained properly to estimate equal distances. More important than the distance of the facility might be whether the latrine is within the compound (on the property) of the household. However if only private facilities are considered improved, the question of the distance can be omitted. It will not be considered in our survey.

Proof of use by all household members

Proof of use of the toilet is probably the most powerful access indicator of all. Use of a sanitation facility indicates that the toilet most likely:

- Is socially acceptable for the users;
- Provides the safety required;
- Offers the comfort needed;
- Can be run at an acceptable cost.

It is more difficult to ascertain the whole household (women, children babies mother-in-law's) use the toilet and on all occasions. For that reason we will only include proof of use and not go into the detail of the whole household using it.

Number of users per cubicle.

As only private toilets are considered as 'improved' there will be no issue of the number of users per compartment. For that reason it will not be considered as a useful indicator.

Design life etc.

Space still available in the pit per person using the toilet will only give information about the future. Latrine maintenance is a similar activity, and information on it is formative, rather than summative. Cost of daily use only is worth considering, but as we are only considering private toilets this will difficult to calculate and have little relevance to the day to day access. None of these will be considered in the survey.

Menstruation.

It is common knowledge that many women and girls in low-income countries use insanitary materials for menstrual absorbent. Depending on the cultural context these will be reused or disposed of in various ways. It's usefulness as an indicator would be worthwhile examining. However in a large population this is socially a very sensitive issue, moreover little literature can be found. It is thus impossible to consider it as an indicator.

Flies and other vectors.

The type of flies that mainly breed in pit latrines are the *Chysomya putoria* and *Chrysomya megacephala* also commonly know as Blowfly (Simpson-Herbert and Wood 1997). It is attracted to excreta, rotting meat and fish. It generally does not travel far. For vector control to be effective it has to be done on a larger scale than the household. So the result of the observation might not be so much a result of the individual household's sanitation as we would like it to be. Moreover, presence of flies can be seasonal. For those reason we consider that the presence of flies and other vectors is not a good indicator for sanitation.

3.4 *Indicators for access to improved water sources*

Water is used for a wide array of activities at household level. The most important are drinking, cooking and hygiene practices. However there is also irrigation and the watering for cattle among the non-domestic uses of water. Not all of these activities need the same amount of water or require similar qualities. Vision 21 does not make the distinction between the different uses.
The only 'universal indicators' used so far are in the WHO's Global Water Supply and Sanitation Assessment 2000 report (GA2000) (WHO and UNICEF 2000) reproduced in annex 2. They are based on the type of drinking water source. In these, bottled water is not considered as an improved water source. The argument is that in most cases water quantity is more important for health than quality (Cairncross 1995; Billig, Bendahmane et al. 1999). Most health benefits are obtained by hygiene practices like washing and not by improved water quality. The GA2000 assumes that bottled water will be too expensive and therefore will not be used for washing. The assumption in the analysis is that in such cases, bottled water is the only source of water.
In the DHS[1] data set 1996 of the Dominican Republic for example, 18% (n=8830) of the households stated that they used bottled water as drinking water source. Of the households using bottled water, 93% (n=1599) have an indoor or outdoor piped connection. This shows that assumptions have to be checked and access to non-drinking water needs to be assessed in order to make an assessment of drinking water provision.
The main differences between drinking and non-drinking water are the quality and quantity needed. For drinking one would hope to have access to a better water quality source but relatively low quantities are required, while for non-drinking purposes, quantity and convenience would be generally more important than the quality. Only if both conditions (access to drinking and non-drinking water) are fulfilled will the Vision 21 access to water criteria be fulfilled.
For this reason we split the indicator for access to water into indicators for drinking and for non-drinking water. In many cases water for cooking, drinking and hygiene might be the same. This is considered in the structure of the questionnaire. Indicators for drinking and non-drinking water will be combined in the criteria of access to water for the Vision 21 target.
Access to water follows a whole chain of events, which are (non-exhaustively):
Source , abstraction, transport, storage, treatment, use. Not all steps may necessarily be present but they must all be considered one way or another in the indicators.
Other consumption patterns may arise but cannot be assumed:

- Outworking man having water intake away from household.
- School child having water intake at school.

Section 3.4.1 considers the aspects of drinking water with a focus on quality while section 3.4.2 looks at non-drinking water an the convenience of collection.

3.4.1 Improved drinking water sources

The definition of "improved" will be based here on the risk of the source being contaminated. This is not an absolute classification as all sources can be polluted, although the risk is higher with particular types. In this part covering drinking water, the water quality will be taken into consideration.

Water sources used for drinking water

When referring to water source one has to keep in mind that the questions are asked at household level, where it will not always be possible to get all the information required.
Definition of drinking water might be important. To simplify, it is the water that is used for drinking rather than for cooking, washing and rinsing utensils if these activities are done with water from a different source.
Surface water
Surface waters include lakes ponds, rivers, streams, canals, dams. They tend to be the most polluted and are not considered as an improved water source for drinking water if they not treated before drinking. Large ground-based rainwater cathments or hafirs will be considered in this category because of their water quality.
Spring water and artesian well
Water from a spring is considered as an improved water source if a covered spring box protects the spring. Getting the right information of the spring protection at the household level will be difficult which makes this type of information unreliable. The diagnostic question to identify whether the water point is a spring is to ask whether the source has continuous flow. To check if it is protected is to ask if any concrete was used around the source or the water comes from a pipe or channel. If not protected this source will not be considered improved.

[1] Demographic Health Survey (DHS III) by ORC Macro[SM] for U.S.A.I.D at http://www.measuredhs.com/.

Ground water

Ground water sources like wells and boreholes (Hand or machine made) are generally sources of good drinking water quality needing no treatment. The main potential source of pollution is through the same hole the water is abstracted. This can be due to the abstraction method or from run-off water if no proper protection is provided. Again this is difficult to assess at household level. There are some ways in which water collection is more likely to pollute the water source than others. For that reason it is suggested that if groundwater is pumped by hand or mechanically, it is considered an improved water source. If water is collected by bucket, bag or other recipient, it is not considered to be an improved water source unless the water is treated for drinking. Infiltration wells will for our purpose be considered as wells, as they will provide similar qualities of water if they are properly built.

Rainwater

Household rainwater (roof) catchments are considered an improved water source. Large ground based rainwater catchments are not considered improved, as was mentioned above.

Piped or tap water

Only if the water is on for most of the day is it considered improved. Intermittent sources will be discussed below. In this survey public stand-posts will be considered in this category when the y supply piped water at the public tap-stand. There is an assumption that if the water source is not intermittent the quality will be improved. This might need checking in some cases.

Tanker truck, vendor

In this case the vendor is considered a mobile vendor and not a static vendor. Households buying water from a fixed vendor are considered under the above categories, according to the type of source de vendor uses. In this survey, a vendor is anybody delivering water to the household.

Bottled water

Water sold in bottles and filled in an industrial facility.

Protected and unprotected sources.

In the GA2000 and the issues paper on V21 indicators, distinctions are made between protected and unprotected sources. For a spring "protection" means a spring box and for a well it means a lining. On the household level it will be difficult to assess whether a source is properly protected. For this reason we suggest that the abstraction method, (for example pump or bucket) is used to decide if the source is an improved water source. It assumed that if the water source has a hand pump it is more likely to be protected by a slab and less at risk from pollution compared to a well were buckets or water bags are used. Perhaps more important than the question whether the well is lined, is the question about the availability of a wall to protect the well against run-off water. It might be difficult for an inspector to know if the well is lined or not when it is covered but it is reasonable to assume that it will be. The question we could ask is whether there is a cover over or a wall around the source if it is a groundwater source or a spring. This question will be in the questionnaire and is open for discussion.

Ownership/level or access to drink water source.

Collecting information on the water source is *public, shared* or *private* seems unlikely to provide extra information relevant to the assessment whether a water source is improved or not. It will not be used in the survey.

Water treatment.

At first sight all activities reducing pathogenic load on-site seem to be beneficial to the consumer even if they only show awareness or concern of the user for the quality of the drinking water. Such home-based water treatment will only offer a health benefit if a significant intake of pathogens is through drinking water. However studies show that while hundreds of faecal coliforms can be found in 100 ml of water, thousands or even hundreds of thousands can be found in every gram of weaning food, in the same households (Cairncross 1995). Moreover home treatment of water is rarely done reliably. In that respect, home or point-of-use treatment should not be considered as leading to improved water. While we reduce pathogens in water we have to look at the efforts and benefits involved in this treatment in relation to what proportion of the daily pathogenic intake is from drinking water

Water quality testing.

There are different ways of testing water to get a better idea of the quality of the water used. In most situations, quality will be secondary to quantity, which would not justify extra efforts and resources in water quality analyses. 'Quick' water testing could be done with tests like e.g. Turbidity, Colilert test, Improved H_2S strips or dip-slides but they would all take time and cost money. Moreover a survey with indicators based this type of testing will be less useful if these test are not available for reasons of access or funding. If there are known local problems of contamination, tests such as for the detection of As, Fl, N can be used. We suggest that water quality testing be kept optional and excluded from the core list of indicators. We note however that UNICEF and WHO are currently conducting a pilot study to develop a workable protocol for the future.

Reliability of the water source.

No water distribution network is free from leaks, but as long as the network is under pressure the chance of pollution getting into the network is low. If however the pressure in the network drops, pollution can get into the distribution network. If the source becomes intermittent, the risk of pollution increases with each cycle of low pressure in the network. For that reason intermittent piped water sources are not considered improved drinking water sources. Other issues in regards to non-drinking water are discussed in section 3.4.2. This indicator will be in the questionnaire.

Time/Distance of water source

There two possible situations in the collection of water. One is that the drinking and non-drinking source is the same, and the other that households use different sources for different applications. As mentioned before non-drinking water is the water used for washing but excludes water uses such as irrigation and cattle. For drinking water the water quality is the most important factor, the quantities needed will be less and so will be the effort if it has to be carried home. On the other hand for non-drinking water the quality is less of an issue but the amounts that have to be transported will be larger and the effort that comes with this activity. To restrict the amount of questions, it would be good to enquire about the source of the drinking water and to ask for the distance or time needed for the collection of the non-drinking water. It assumes that the effort of collecting drinking water from another source is acceptable to the household (not seen as a constraint). This makes the collection time/distance to the drinking water source less relevant for drinking water than the for non-drinking water and will for that reason not be included as an indicator for drinking water. It will however be considered in paragraph 3.4.2 on 'Indicators for access to non-drinking water'. Where there is no differentiation of sources both, questions will automatically be about the same source.

Physical accessibility to the water

Terrain, reliëf, opening hours and queuing time are important factors in determining whether people have access. With the exception of queuing time, they are difficult to measure. Most of them become more important when the amount of water needed increases, as is the case for non-drinking water. They will also be reflected in the time needed to collect water and will for that reason not be included as a separate indicator for drinking water.

Water quantity

As the amount of drinking water collected is relatively low compared to the amount of water needed for non-drinking purposes and in many cases both uses cannot be differentiated anyway, water quantity will be discussed under paragraph 3.4.2 on 'Indicators for access to non-drinking water'.

Amount of trips

The number of water collecting trips made per day are related to quantity of water collected and will be consequently discussed in paragraph 3.4.2 on 'Indicators for access to non-drinking water'.

Energy needed to abstract and transport the water.

Some people will have to put a lot of effort (energy) in obtaining water in relation to their daily calorific intake. This effort will be in relation to the amount of water collected and will for that reason be discussed below in paragraph 3.4.2 on non-drinking water.

3.4.2 Indicators for access to non-drinking water

Time/Distance of water source

It has been shown (Cairncross and Feachem 1993) that if between 3 to 30 min time is needed (round trip) for water collection, the amount of water collected varies little with the distance. If more time is needed the amount of collected water drops. Activities such as going to and returning from the water point, queuing and pumping are included in this time while socialising (when not queuing), washing clothes and utensils at the water point are not.
The distance could also be expressed in meters but at household level estimations of time are generally more accurate. Moreover time will take account of factors such as pumping, climbing steep paths and difficult terrain while distance will not. Other alternatives are to collect distance data by questions or measurements.

Physical accessibility to the water

As mentioned above, terrain, opening hours and queuing time energy needed (e.g. to pump up the water) are important factors in determining whether people have access. With exception of queuing time, they are difficult to measure. Most of them become more important when the amount of water needed is large as is the case for non-drinking water. They also will be reflected in the time needed to collect water and will for that reason not be included as a separate indicator.

Reliability of the water source.

Intermittent water sources limit access to water, which can limit the amount of water used. Because hygiene needs more water it will suffer first under an intermittent water supply. Other sources will have seasonal variations, which are discussed below. This indicator will be in the questionnaire.

Water quantity

There are some problems with the choice of water consumption as an indicator. As most of the water used at the household level is for non-drinking purposes like washing, it might be an indicator for hygiene behaviour more than to access. Measuring it at the household assumes that all the water used, is brought to the household. People will wash themselves, their clothes or cooking utensils close to the water source. Even collecting larger amounts of water does not imply that it is used for hygiene purposes. Practically it is difficult to measure the consumption and moreover it has to be measured in relation to the assumed need.
In relation to access it would be better to know if people can take as much water as they want and if they can without any problem increase the amount of water they collect. To assess whether people use as much water as they want, within the constraints they face, involves posing hypothetical questions which households will find difficult to answer. As the collection time, discussed earlier is a major determinant in the amount of water collected it seems superfluous to collect information on amount of water collected. For the above mentioned reasons it is best not to consider water consumption as an indicator.

number of trips per day to collect water

If more trips are done it might be an indicator of easy access. But more trips might indicate a higher consumption rate, which is related to hygiene behaviour more than to access to water. The same confusion may exist with this indicator as with water quantity mentioned above. It will for that reason not be used in the survey.

Energy needed to abstract and transport the water.

Where water sources are far away from the household, or water is hand-pumped from a deep acquifer, or when the altitude difference between household and water point is considerable, it is likely that the energy in obtaining water is high in regards to their daily calorific intake. There is no easy way of collecting this data. It is however indirectly expressed in the time people need to collect water and so will not be considered as a separate indicator.

Cost of water

Water budget versus household budget or the ability to pay is certainly a critical factor in the consumption of water. On a regional level it is possible to set a price criteria adapted for the local situation. This would be adapted to the average income. There are no universal criteria to set this level. For that reason it is suggested to keep it as an optional indicator in the survey.

3.4.3 Other aspects to access to improved water sources

Seasonal variations

Seasonal variations in water supply are not straightforward to assess in particular in nomadic and semi-nomadic populations. It is difficult to express seasonality in a simple yes or no. If a household has 10 months of access to an improved water source and two months no access according to our indicators does that mean they have no access? Recommendations that the survey is best held when water is scarce might be a good an idea. However the dry season is not necessarily the worst case for access to improved water sources. Timing the survey in a specific season may not always be realistic. Asking questions on situations during the dry season could lead to recall and strategic bias. We recommend that season and the global water situation is briefly described for each survey. A brief questionnaire will be drafted for that purpose. It is a point, which needs discussing.

Water storage

Size of water storage could be an indicator for:

- Intermittent water supply
- Good hygiene practice because of high water consumption
- Short distance to water source so no need to store a lot.

As it can indicate a wide variety of things, it is likely to be an ambiguous indicator and will not be considered. If there are two types of water stored at the household level it seems that there is little rigour in their dedicated use (Zeitlyn 1994; Hoque, Mahalanabis et al. 1995) which makes this distinction at household level not a useful one.

Maintenance of water source

This information has to be collected at the water source rather than on at household level and will for that reason not be considered.

Other activities related to water sources

Water conservation by prevention of water pollution and ecological degradation are factors that are not unimportant but not relevant to the V21 indicators.

4 Indicators for hygiene education in school

It is important that hygiene education is incorporated in the schools curriculum. Opinions differ as to whether it needs to become a subject in its own right, or whether it should be part of a wider syllabus of health education (UNICEF 1998). However what happens in schools in often varies from what the ministry of education has determined. If there is no national policy of inclusion of hygiene in the school curriculum, in standard textbooks and in teaching materials and examinations, it is unlikely that there will be much health education in the classrooms.

For assessment of the hygiene behaviour of boys and girls UNICEF suggests to look at:

- Safe drinking
- Safe water handling and storage
- Washing hands after defecation and before handling food
- Children using latrines for defecation
- Children using latrines or urinals for urination
- Regular cleaning of facilities
- Covering food

Adapted from (UNICEF 1998)

Vision 21 has as targets that 80% of school children should be educated about hygiene by 2015 and 100% by 2025 (see annex 1). As the students are the basic sampling unit (see paragraph 2.2) it would be easier to test their knowledge of hygiene behaviour than to ascertain whether they have been educated about it (see paragraph 2.1.4.) This would not only prove they have been *adequately* taught about hygiene but that it was done in such a way that it was *understood.* It also avoids making judgements on appropriate teaching methods and the availability of didactic materials.

Even among primary school children (± 6 to ±12 years old) the degree of knowledge on hygiene will vary widely. Which students, what age group, should have full knowledge on the questions asked on hygiene? We would expect that final year students would be much better informed than the first years. The first years might still be in the process of acquiring hygiene practices, while the last year will not be representative if there are high drop out rates. For that reason we would at least exclude the first year students out of the survey. Not only should we know which students to include but also which primary schools to include in the survey. Primary schools can be private, state, religious or other types of school. Not all of these schools will allow surveys being done. Excluding some of the schools might lead to an unrepresentative sample while not obtaining access to included school, a high non-response rate. We would suggest for this survey that only state schools would be sampled.

In many ways they set the standards as they are governed by the state who set schools standards but also because other schools will try to better than the state schools because they have to competitive. Private and religious schools have generally more resources, which enable them to have better infrastructures. If the survey is a governmental endeavour it will easy to obtain access to state schools which solves possible access problem.

School children are the basic sampling unit for this target. This means that they will have to be examined on their individual knowledge. There are various ways of doing this.

<u>Show of hands</u>

This would give a quick idea of the knowledge of children present in the class. It might influence clearly other students and might not be as representative to measure accurately the knowledge of the students.

<u>Written questionnaire</u>

Some schools will not have the habit of written 'exams'. Moreover this would create the need to translate all the questionnaires into different languages and a lot of testing to see if they are culturally appropriate.

Another alternative to written questions is to use drawings, but despite them being less language dependent they will still have to go through rigorous testing.

<u>Demonstrations</u>

Demonstrations of practices like handwashing have been suggested but the time needed and the difficulty of testing it without the children being influenced by teachers or other pupils makes this method less appropriate.

A good intermediate solution could be to have a small questionnaire read by an interviewer and a simple answer sheet in which the pupils have to put a circle or a cross in relation to the answer.

Suggestions of some questions are:

- Is it better to wash your hands apart, or together?
- Can you get unwell from flies on your food or not?
- What is the most important, to wash your hands before or after defecation?

- Which water is better for drinking, from the river (pond) or from the well (pump)?
- Why should you wash your hands with soap (ash, sand)?
- What is the most important, to wash your hand before of after eating?
- What should be done with the excreta of all young children such as your little brothers' or sisters'?

These questions have been discussed more detailed in the draft list of indicators accompanying this document. The methodology does not prove the knowledge was acquired at school.

5 Indicators for access to improved sanitation in schools

This indicator will be only looking at the availability of toilets for students and handwashing facilities. It will not look at proper management and maintenance of the infrastructure but just to the situation as it is. If national standards are set than these will have to be incorporated in the survey.

For sanitation the following needs attention:

- Presence of latrines for boys, girls and teachers;
- Cleanliness of the latrines and presence of cleansing materials;
- Drainage of waste water;
- Garbage disposal;
- Accessibility of the latrines for the entire school population;
- Appropriateness of the design.

Adapted from (UNICEF 1998)

'Appropriate' also means that the community members can copy the sanitary and (if possible) water-supply facilities constructed at schools for their own purposes (UNICEF 1998).
UNICEF recommended three types of excreta disposal systems for schools in developing countries: pit latrines, ventilated improved pit latrines (VIPs) and pour flush latrines (UNICEF 1998). They recommend the use of flush latrines in schools unless water provision is a problem or solid anal cleansing materials are used. In that case VIP latrines are the best option according to UNICEF.
As an indication UNICEF suggests that one latrine is required for each twenty students (UNICEF 1998) Other sources suggest figures going up to 50 students per cubicle.

When planning the number of latrines for a school, certain issues should be considered:

- What is the proportion of boys to girls? If urinals are available, boys need fewer latrines.
- Are children allowed to leave the classes to use the latrine? If not, pressure on latrines during breaks is great and more latrines are required.
- Do all children have breaks from classes at the same time? If so, more latrines are required. Could breaks be staggered?

Adapted from (UNICEF 1998)

So the series of question for the toilets would be:

Do the students have a break all together at the same time? Y/N
If yes ...
How many girls you have at the school? (=*g*)
How many boys at the school? (=*b*)
(Do not use the student capacity of the school but the actual numbers 'registered'.)
If no ... (Likely to result in less accurate answers)
What is the maximum of girls having recreation at any time during the day/week? (=*g*)
What is the maximum of boys having recreation at any time during the day/week? (=*b*)
The amount of toilets needed for girls has to be (=*tng*) >= *g/q*
The amount of toilets needed for boys has to be (=*tnb*) >= *b/q* of which max 1/2 may be urinals.
The maximum amount of persons per cubicle (=*q*)varies from 20 (UNICEF), 30 (WHO) to 50
In Uganda it is 25 pers./cubicle up to 100 students and then 40 pers./cubicle. Is no standard is available we suggest (q=25) although this is open to discussion.
The amount of toilets available for girls (=*tag*) (exclude any toilet that is for exclusive use of the staff!)
The amount of toilets available for boys (=*tab*) (exclude any toilet that is for exclusive use of the staff!)

Girls' toilets have to be separated and least 20 m away from the boys' latrines if not *tag = 0.*

Cubicles for boys or girls are only counted if they:

- have super structure that gives enough privacy. (e.g. proper door, walls etc.)
  - are a pit latrine with floor and a small drop hole or.
  - are flush latrine and water for flushing is available.
- The toilet is clean around the drop hole/closet.
- They are maximum 50 meters/paces away from the classrooms

Coverage for girls would be: $cg\ \% = |tag/tng| x100$
Coverage for boys would be: $cb\ \% = |tab/tnb| x100$
Total coverage school would be $tc\ \% = |[(cg*g)/(g+b)] + [(cb*b)/(g+b)]|$
If not 100% the school does not have access to sanitation.

So the series of questions for handwashing facilities would be:

- Is there water available for handwashing? Y/N
- Is there soap, ash or sand available for handwashing? Y/N
- Are there enough washing points available for the number of latrines? (not in relation to students)

There are few guidelines on the number of washing points in relation to the number of cubicles. If we assume that it is *r* cubicles/washing point than is the coverage and *wa* is the number of washing points available than is the coverage $|r.\lfloor wa/(tag+tab)\rfloor|$

If the value is not 100% the school does not have sufficient access to improved sanitation.

The information will be based on spot observation.

In this target schools are defined as the basic sampling unit. With the data available we would also be able to calculate the percentage of students having access to sanitation at school by using students instead of schools as basic sampling units.
As it is, school have or have not access to sanitation if they have or have not access for all (100%) of the students to improved sanitation. If all the schools within the survey only cover 70% of their sanitation needs this would result in all the school having insufficient access to sanitation or o% have access to improved sanitation. If however students would be the BSU instead of the schools this would result in 70% access which is more representative of reality.

Lack of facilities and poor hygiene affect both girls and boys, although poor sanitation conditions at school have a stronger negative impact on girls. All girls should have access to safe, clean, separate and private sanitation facilities in their schools. If there are no latrines and hand-washing facilities at school or if they are in a poor state of repair, then many children would rather not attend than use the alternatives. In particular, girls who are old enough to menstruate need to have adequate facilities at school, separate from those of boys. If they don't, they may miss school that week and find it hard to catch up, which makes them more likely to drop out of school altogether. Many children, again mainly girls, miss out on time at school because they are having to walk long distances in order to fetch water. Also in schools, when the schoolteacher sends children to fetch water, it is predominantly girls who are sent.

6 Testing the indicators

One of the major problems in measuring hygiene practices is that there is no 'Gold standard' (Manun'Ebo, Cousens et al. 1997) to refer to or to compare with. Moreover we use, as mentioned in paragraph 3.1, indicators as practically useful surrogates for the direct measurement of performance. We assume they express accurately enough the critical aspects of the performance, or in other words that they correlate with reality. We want to assure ourselves that they lead to a result we would also have obtained through more thorough analysis (validity), and that they are reliable enough to lead each time to the same result (reliability). In other words, we want to know how valid the conclusions are when based on the information collected, and also how good is the repeatability of the methodology.

<u>Reliability</u>

Reliability is regarded here as the degree to which repeated surveys will yield the same results. This could be affected by the validity of the proxy indicators used and is discussed below. It is also dependent on the consistency of the way in which the interviewer or interviewers collect data and classify observations. In our survey the indicators are kept as simple as possible and the outcome is a set of summative binomial value. This should allow for more easy consistency than possible in similar formative surveys. It is still essential to get the right selection and training of interviewers. This can be achieved according to Kendall and Gittelsohn (1994) by:

- selection of observers using criteria for education, experience and familiarity with the site;
- training and standardisation of scoring to exacting levels of reliability; and
- most critically, suitable for the survey design.

Training of interviewers will be essential to increase the reliability of the survey see section 7.

<u>Etic Validity on household level</u>

Traditional ways of assessing water, sanitation and health issues are open-ended questions and structured observations as mentioned in paragraph 2.5. This paragraph also mentioned the advantages and limitations of these methodologies. One of the major disadvantages of structured observations is that they need trained staff, a lot of time and are consequently expensive in implementation. To evaluate our survey methodology we could select randomly some of the households previously sampled in the survey and do *structured observations* (without knowing the previous results) and check if they lead to the same conclusion. This would lead to analysis of the etic validity on a household level. This method would also allow to check the assumptions that were made for the selection of the indicators and how important those assumption are in regard to the result.

Emic validity on household level

After comparing both results we could return to the household and discuss the results with them, to see if the concept we have on access to water, sanitation and the use of hygiene practices is similar to the perceptions of the household on these issues. This would allow us to see in how far our indicators and results are acceptable to the household and which factor might have been overlooked in the survey design.

Emic validity on community level

All the above are evaluations done on a household level. When feeding back to the community we could check through *group discussions,* how far the conclusions drawn from the survey, correspond with what they think is true. It has been noted that some communities have a good idea themselves on water and sanitation coverage as well as the application of hygiene practices, according to the way they understand these terms. Differences and similarities could be discussed. One of the major questions on the emic validity on community level is 'who is representative of the community'. As discussed in paragraph 2.3 it is 'women of the house' which represents best the household as a BSU on issues relating to hygiene practices and access to water and sanitation. As a group it will be women's organisations that will be most likely to be representative for community on the same issues.

Some statistical tools like Kappa statistics (although controversial), Chronbach's alpha, latent class/trait models have been designed to evaluate inter observers ratings and validity of indicators. These will be evaluated and applied when relevant in the test phase.

7 Training of interviewers

Many problems are likely to arise in the process of data collection if in sufficient attention is given to details at the preparatory stage of the data collection (Kochar 1994). The standardisation of methodologies like interviewing and observations by the fieldworker will be important to obtain correct and reproducible data. There is a widespread misconception that hygiene behaviour studies have to be undertaken by highly trained specialists (Boot and Cairncross 1993). Because summative data is collected on well-determined questions, the degree of freedom is so limited that design of survey allows non specialised fieldworker to collect the data. Still there is a need for a least a modicum of training in order to standardise the questioning and observations and obtain a high standardisation in observation. This will increase the reproducibility of the results.

The choice of interviewers might strongly influence the outcome and hence the validity of the survey trough strategic bias. If staff of the water department do surveys, they will want to get a high coverage on 'access to water' because that shows they are doing a good job. Beneficiaries or local communities might want a low outcome of a survey to shows low coverage and high needs. The interviewer is more than the interviewee in a position to influence the outcome of a survey. The goal of the training would be to explain as clearly as possible what information we need and how to collect it but at the same time it would be best not to reveal the full objectives of the data collected.

A training program will be designed based on basic training, role plays, fictitious and real situation analyses, pictures and videos to standardise as much as possible the data collection methods between the interviewers. Techniques like participatory training will be used to clarify the interviewers understanding of the questions and observations plus the data we want to obtain trough them.

8 Practical imputation and treatment of data

In many surveys, the time between data collection and analyses is long because of they way the questionnaires are coded into a analysable format and the way the data is analysed. Not only do we have to make sure data is collected accurately but also we have to make sure this accuracy is not lost while encoding the questionnaire information into a data file suitable for analysis. Because the information collected is summative there is little chance to detect imputation errors after the data is put into a data file. To allow timely and 'error-free' encoding of the survey information, we would suggest that barcodes are looked at as a possible tool. At the same time we would urge to examine if a system can be found in standard software packages to analyse the survey data which allows the user to add more questions and analyses. An example of a possible bar-coded question is given in annex 4 Figure 2 on page 445.

E.g. Barcodes would allow a quick reading of the questionnaires with little potential for mistakes. They can be read with 'cheap' RS232, USB or keyboard wedge barcode readers.

Annexes

1 Vision 21 Targets

	Vision suggested targets for 2015	for 2025
1	Universal public awareness	Good hygiene practices universally applied
2	Percentage of people who lack adequate sanitation halved	Adequate sanitation for everyone
3	Percentages of people who lack save water halved	Safe water for everyone
4	80% of the children educated about hygiene	All primary school children educated about hygiene
5	All schools equipped with facilities for sanitation and hand-washing	
6	Diarrhoeal disease incidence reduced by 50% (indicator considered for health sector)	Diarrhoeal disease incidence reduced by 80%

2 Global assessment indicators

Table 1 contains the 'definitions' used by UNICEF and WHO in 'Global Water & Sanitation

Following technologies are considered '*improved*'.

Water supply
- Household connection
- Public standpipe
- Borehole
- Protected dug well
- Protected spring
- Rainwater collection

Sanitation
- Connection to a public sewer
- Connection to a septic tank
- Pour-flush Latrine
- Simple pit latrine
- Ventilated improved pit latrine

Following technologies are considered '*not improved*'.

Water supply
- Unprotected well
- Unprotected spring
- Vendor-provided water
- Bottles water
- Tanker truck-provided water

Sanitation
- Service or bucket latrine (with manual labour)
- Public latrines
- Latrines with an open pit

Table 1: Definitions used in 'Global Water & Sanitation Assessment 2000' (WHO-UNICEF, 2000)

3 Faecal-oral transmission routes

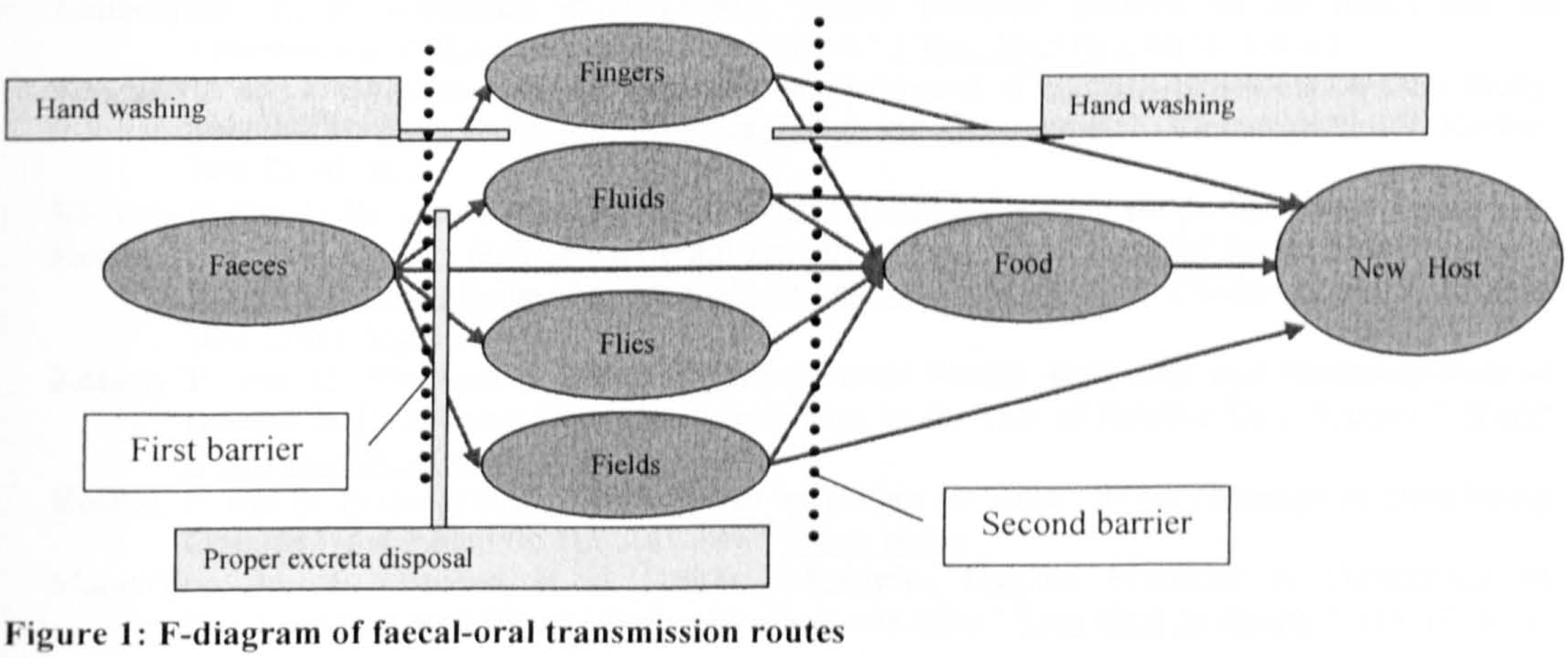

Figure 1: F-diagram of faecal-oral transmission routes

4 Bar-coded questionnaires

Question

Is the toilet your household uses a:

QC02A01 ☐ **Private** used only by your family;

QC02A02 ☐ **Shared** used by more families but they are known to you;

QC02A03 ☐ **Public** available for use by anybody.

Figure 2 : Example of a bar-coded questionnaire

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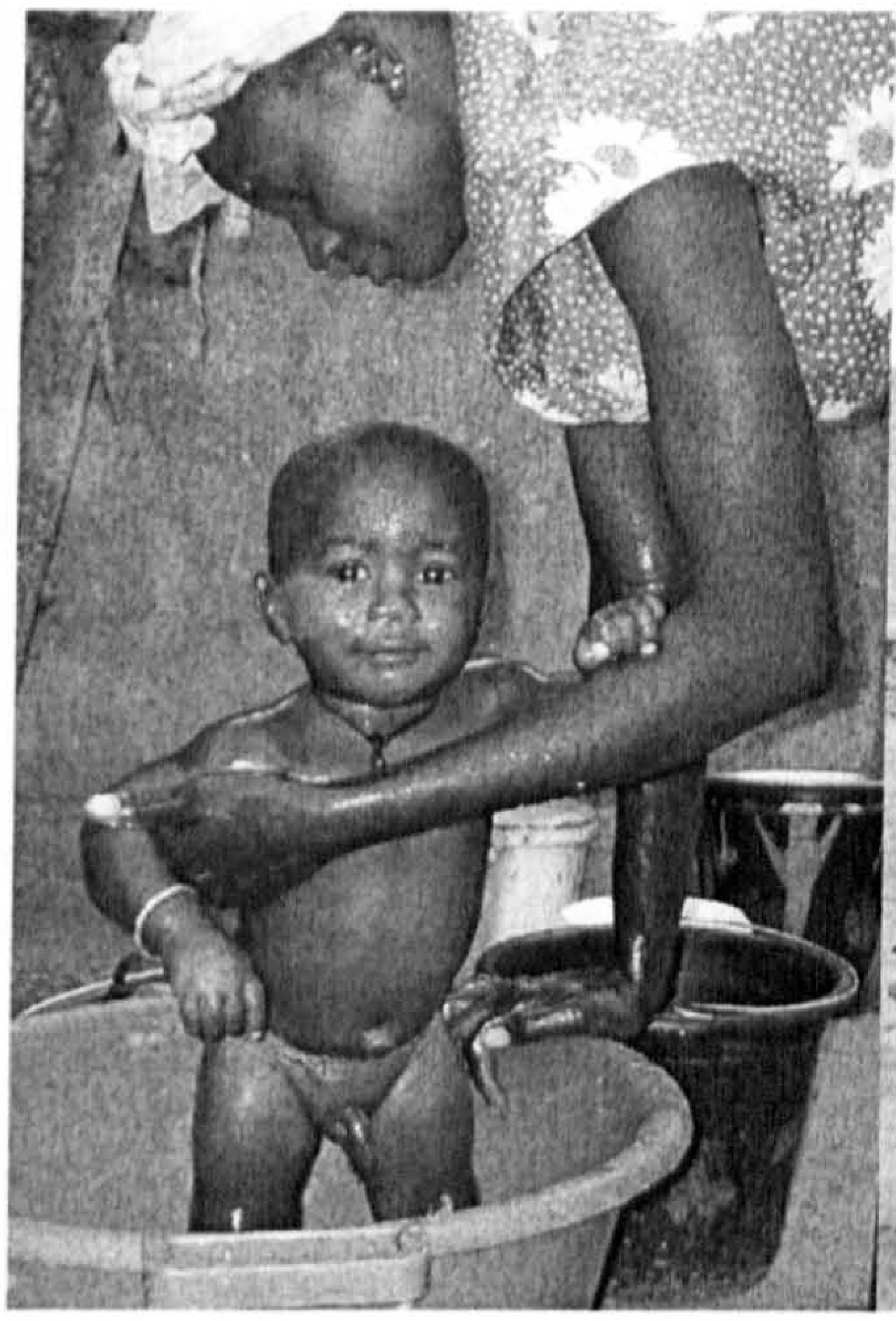
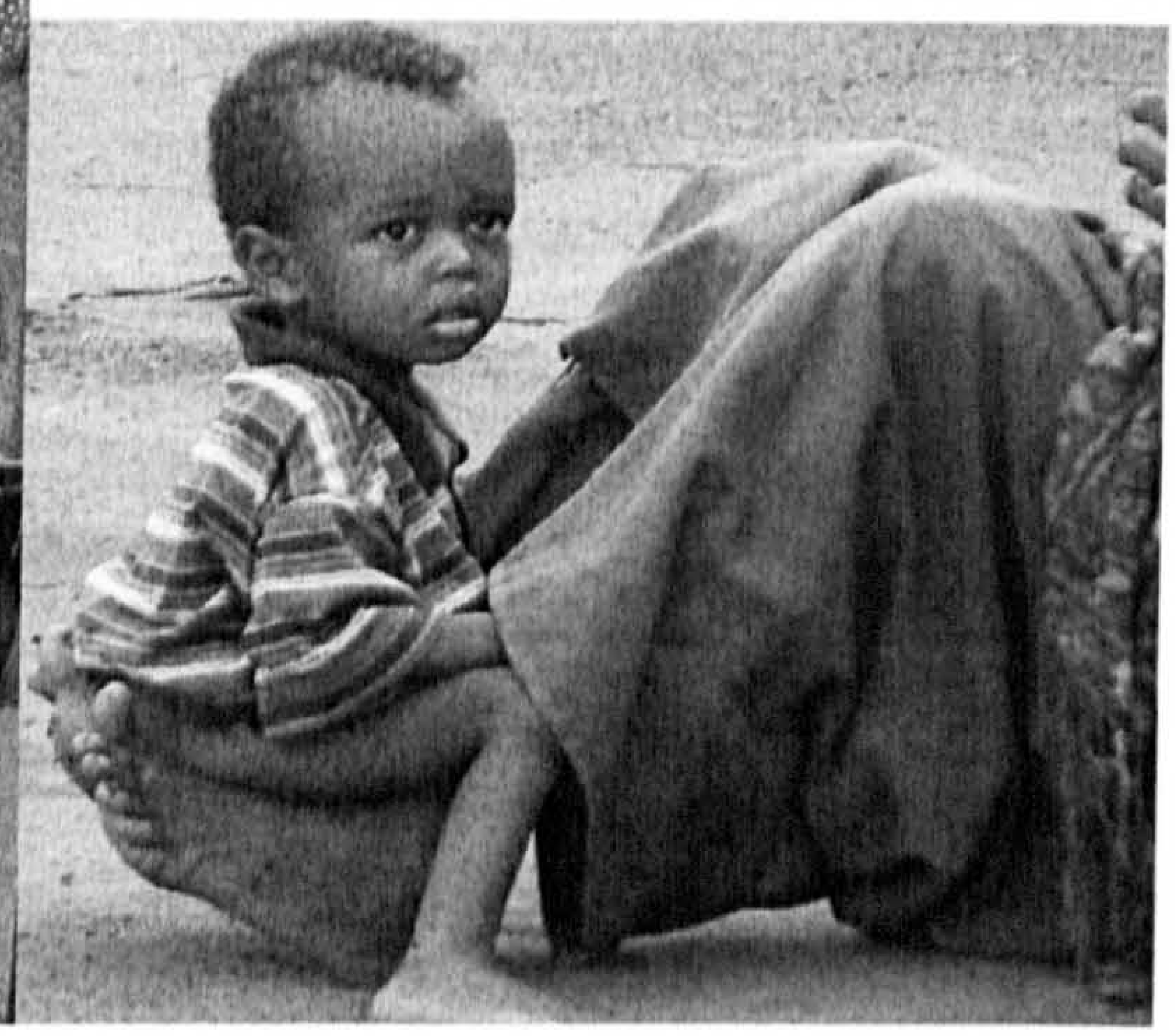
WSH Indicators for VISION 21

Deadline: **15 August 2002**





Comments or suggestion on this document or issues relating to it are welcomed:

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Glossary

BSU	Basic sampling unit
DHS+	Demographic Health Survey plus (USAID)
EHG	Environmental Health Group at LSHTM
GA2000	Global Water Supply and Sanitation Assessment 2000 (WHO and Unicef 2000)
HH	Household
HW	Handwashing
IAP	Iguaçu action plan
JMP	Joint Monitoring Programme of UNICEF and WHO
ITD	Infectious and Tropical Disease Department at LSHTM
LSHTM	London School of Hygiene and Tropical Medicine
UNICEF	United Nation International Children Emergency Fund
V21	Vision 21
WHO	World Health Organisation
WSH	Water, Sanitation and Hygiene
WSSCC	Water Supply and Sanitation Collaborative Council

Before you reading this document.

The document has different parts as illustrated below. The first bloc contain the household questionnaire with targets one to three but contains also the questionnaire for primary schoolchildren to be interviewed at the household level. The second bloc contains the questionnaires for targets four and five which are related to primary schools.
The last bloc contains the rational of the different questions, annexes and bibliography.
For targets four and five there is some repetition between questionnaires at the household level and at the school level. The same repetition exists on hygiene related questions between household and school questionnaires.
In reality there are three questionnaires in all.
The **first** one is the household questionnaire collecting information on hygiene practices, access to sanitation and access to water sources in the household. In the household questionnaire there is also a **second** questionnaire to be asked to every primary school child in the household collecting information on Vision 21 targets four and five on school hygiene and sanitation. The **third** questionnaire concerns the school targets in Vision 21.

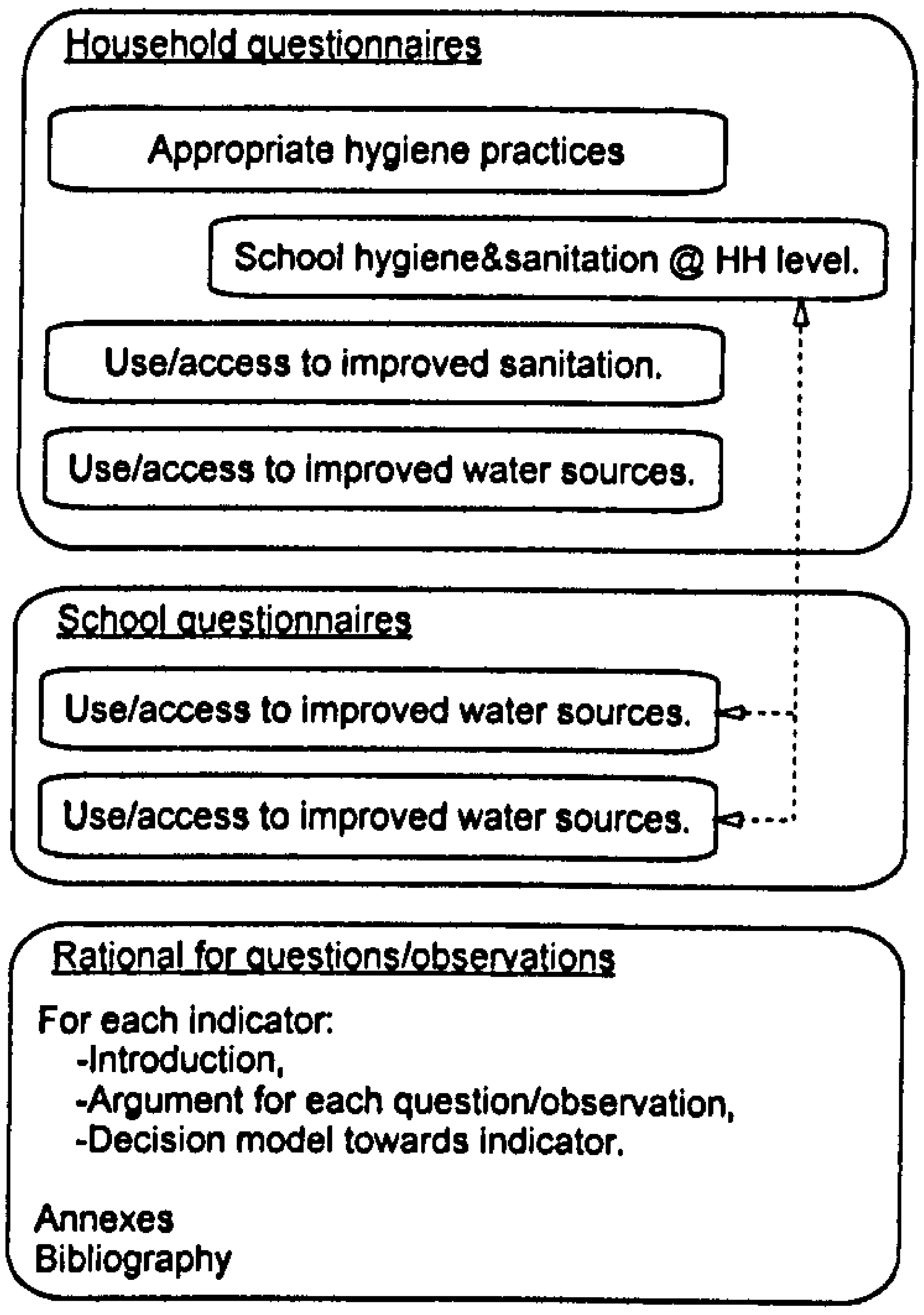


Figure 1: Structure of the document.

The order of questions in this document follows the ordering of vision 21 targets, to make the rational for them more intelligible. In the final questionnaire, a different order will be followed. For instance observations will be separated from questions, and delicate and stigmatised questions placed near the end. More information on detailed guidance for field workers on sampling coding will be provided
There various types of question as explained below.

Core question

Core observation

- **Core questions** are the minimum set of standardised question and observations on which the value of the indicators is set.

Optional question

Optional observation

- **Optional questions** are optional standardised question which can give extra information on survey results.
- **Additional questions** are locally added questions which can give extra information and are adapted to the local situation. There are no additional questions in this paper.

In the rational for the questions (section F on page 471) the only a distinction made is between questions and observation. In the rational it is stipulated why questions are core or optional.

Who to targeted as interviewee for the different questions and why, is explained in the arguments of the proposed questions in section F on page 471. Section G.6 on page 502 contains brief information on how to mark the answers as an interviewer.

We recommend to keep questions and arguments as separate documents for easy reading!

General household sampling information

Reference of the survey	code
Reference of the surveyor 1. 2.	Code
Reference of the household	Code
Name of interviewee	Code
Adult Man ☐ / Woman ☐ (Only adults should be interviewed; A man should only be accepted as an interviewee if he is involved daily household tasks and there is no adult women in the household) How many children in this household are going to primary school? (QA8) Number of children going to primary school No children going to primary school 96	This is to determine the number of interviews of primary school children at household level.
Reference of the location (Make sketch of location on the back of this paper if there is no formal address)	Code
GPS location if available Projection system: Latitude Projection datum: Longitude	Note Lat. & Log in **degrees and decimals.** clearly specify format if different format used!
If refused, detail reason for refusal. Give full details ☐ Refused → reason: ☐ Not home → Plan revisit ☐ Accepted	Code
Date/ Time of the interview Date 2 0 0 Time start : Time end : Duration (min)	Code
Remarks	Code

A Appropriate hygiene practices.

A.1 Where do you usually wash your hands?

Coding categories		Go To	Remarks
In dwelling/yard/plot	1		
Somewhere else	2	→ A.3	
Nowhere	3	→ A.4	Rarely or never wash my hands.

A.2 Ask to see the place and observe if the following items are present.

Coding categories	Yes	No	Go To	Remarks
				If item can not be shown in approximately **3 minutes** than mark No.
A] Water/~~Tap~~	1	2		
B] Soap, ash or other cleansing agent	1	2		
C] Basin/*Bucket/Sink*	1	2		
D] *Distance between place and toilet (m).*				Optional answer not used towards the value of the indicator. (Value in meters) Write 999 if no toilet available.

A.3 When do you usually wash your hands in order to keep healthy?

Coding categories		Go To	Remarks
*DO **NOT** READ OUT THE ANSWERS. MARK THOSE MENTIONED.*			You may prompt the interviewee to give **maximum three** answers.
A] Before going to the toilet	11		
B] Before handling food (cooking/eating)	13		
C] Before cleaning child's bottom	15		
D] Before leaving the house	17		
E] After going to the toilet	21		
F] After eating	23		
G] After cleaning child's bottom	25		
OTHER_(1) ______________________	96		
(2)______________________	97		
(3)______________________ (Specify)	98		

A.4 Are there children's faeces in or around the household area, or not?

Coding categories		Go To	Remarks
Yes, there **are** faeces around the household area.	1		Any faeces of apparently human origin are considered during the observation.
No, there are **no** faeces around the household area.	2		

A.5 What ~~is usually~~ *was* done to dispose of your (youngest) child's stools (diapers) ~~*when*~~ *the last time* he or she ~~*does*~~ *did* not use any toilet facility?

Coding categories		Go To	Remarks
Child always use toilet/latrine	01		Text in *italics and blue* are modification of the original question as explained in the rational of the questionnaire below.
Thrown into toilet/latrine	02		
Thrown outside the dwelling	03		
Thrown outside the yard	04		
Buried in the yard	05		
On waste heap, in open waste pit or ~~open~~ bin	*11*		Consider open **burning** in this category as it is unlikely to be burned daily.
In covered bin for regular collection	*12*		If bin is **not regularly collected** mark where the bin is emptied!
Rinse away *in sink or to drain*	06		Proper waste water disposal is needed for this option if not select '09'.
~~*Use disposable diapers*~~	~~07~~		If a '**potty or diaper**' is used it is the disposal of its contents that is relevant in the question.
~~*Use washable diapers*~~	~~08~~		
Not disposed of	09		
OTHER ______________________________ (Specify)	96		
No young children (0-3 years) in household	*99*		

A.6 What does the household use as a drawing mechanism for drinking water?

Coding categories		Go To	Remarks
Tap	1	➔A.8	Tap on local tank or directly on the piped distribution network.
Cup or ladle	2		Any method of scooping water out of a 'container' with a e.g. mug or scoop.
Hands	3	➔A.8	
OTHER ______________________________ (Specify)	9		

A.7 Ask to see the stored drinking water, and observe the way water is drawn from the container

Coding categories	Yes	No	Go To	Remarks
A] Is it likely that the hands get in contact with the drinking water?	1	3		e.g. is the cup stored on the bottom of the water container this is the case.
B] Is the cup/ladle kept in a dedicated place free from contamination?	1	3		e.g. if the cup is stored on the ground it is likely to pollute the water when used.

A.8 School sanitation questionnaire at the household

All questions A.8…are part of a separate survey targeting primary schoolchildren in relation to hygiene education and knowledge.
This survey should be repeated for **ALL** primary school children in the household separately.

Child Nr. [ ] of [ ] children

Name of the child	**A.8.a Age of child in years**	**A.8.b Sex of Child (M/F)**
Name of School		Reference of school

A.8.c Which is the most important thing to do for your health?

Coding categories		Go To	Remarks
A] Hand washing after eating	11		Read the question and all the answers out loud **twice** and allow **one** answers after the second reading.
B] Brush hair	13		
C] Cut fingernails	15		
D] Take a bath	19		
E] Have clean clothes	21		
F] Brush teeth	23		
G] Have clean ears	25		
H] Take shoes off when entering house	27		
I] Wash hands after toilet	29		

A.8.d What disease is caught from excreta?

Coding categories		Go To	Remarks
A] Malaria	11		Read the question and all the answers out loud **twice** and allow for **minimum one** and **maximum two** answers after the second reading.
B] Diarrhoea	13		
C] Pneumonia	15		
D] Measles	17		
E] Cholera	19		

A.8.e When do you usually wash your hands?

Coding categories		Go To	Remarks
*DO **NOT** READ OUT THE ANSWERS. MARK THOSE MENTIONED.*			You may prompt the interviewee to give **maximum three** answers.
H] Before going to the toilet	11		
I] Before handling food (cooking/eating)	13		
J] Before cleaning child's bottom	15		
K] Before leaving the house	17		
L] After going to the toilet	21		
M] After eating	23		
N] After cleaning child's bottom	25		
OTHER_(1) ______________________	96		
(2)______________________	97		
(3) ______________________ (Specify)	98		

A.8.f Where do your friends defecate when they are at school?

Coding categories		Go To	Remarks
DO **NOT** READ OUT POSSIBLE ANSWERS.			
School toilets	1		
Bush/field	31		If they are not school toilets mention whose they are!
OTHER______________________ (Specify)	96		

A.8.g Do you have to queue most times when you want to use the toilets at your school?

Coding categories		Go To	Remarks
Yes, I have to queue most times at school toilets.	1		
No, There are **enough** toilets at the school.	3		

A.8.h Are the toilets for boys and girls separated?

Coding categories		Go To	Remarks
No, no separated toilets	1		
Yes, clearly separated toilets	3		
Not a mixed sexes school	9		

A.8.i Is there a place for handwashing at your school?

Coding categories		Go To	Remarks
Yes, Enough handwashing facilities at our school	1		
Yes, Not enough, children usually have to queue.	3		
Yes, But almost **not used**	5		
No No handwashing facilities at my school.	7		

A.8.j Do the handwashing facilities have:

Coding categories	Yes	No	Go To	Remarks
A] Water	1	3		
B] Soap, ash or other cleansing agent	1	3		
C] Basin/bucket/sink	1	3		

A.8.k Have you been taught about hand washing at school?

Coding categories		Go To	Remarks
Yes	1		
No	3		

A.8.l Does the teacher send you home if you arrive at school looking dirty?

Coding categories		Go To	Remarks
Yes	1		
No	3		

B Use/access to improved sanitation

B.1 What kind of toilet facilities does your household use?

Coding categories		Go To	Remarks
FLUSH TOILETS			
Flush to sewage system or septic tank	11		Toilet/latrine with water seal, connected to sewage system or septic tank.
our Flush latrine (water seal type)	12		Same as above but not connected to sewers or septic tank.
PIT TOILET/LATRINE			
Open ~~traditional~~ pit latrine	21		Toilet/latrine from which the pit is clearly visible and no clear small drop-hole.
Covered ~~traditional~~ pit latrine	22		Toilet/latrine with floor mounted above a pit and a clear small drop-hole.
Ventilated improved pit (VIP) latrine	23		
No facilities/bush/field	31	→C1	
Bucket, night soil or service latrine	41		Has to be emptied regularly and transported for disposal
Overhung latrine	42		Latrine built over river, pond or any other water source.
OTHER______________________ (Specify)	96		

B.2 Do you share these facilities with other households?

Coding categories		Go To	Remarks
Yes	1		Question do determine if toilet is private or not.
No	3		

B.3 Do you share these facilities with other people you don't know?

Coding categories		Go To	Remarks
Yes, I share this toilet with people I don't know	1		Question to determine if toilet is shared or Public.
No, I know all the people that use this toilet.	3		In village it is difficult to have 'Public' latrines which is logic under this definition.

B.4 Do you have to pay to use to the toilet EACH TIME you go?

Coding categories		Go To	Remarks
Yes, I pay each time I use the toilet	1		
No, I pay periodical fee (e.g. monthly fee)	3		
No, I pay nothing at all	5		

B.5 Does the toilet show signs of regular use and has good access

Coding categories	Yes	No	Go To	Remarks
A] Road to toilet is clear and used?	1	3		If **indoors** mark yes unless inaccessible.
B] Cubicle shows sings of recent use?	1	3		E.g. presence of anal cleansing material.
C] Easy accessible day and night?	1	3		If **key** is not in the household mark NO
D] Not more than 50m or 50 paces away?	1	3		

B.6 Is the drop-hole/closet free from visible excreta?

Coding categories		Go To	Remarks
Yes,	1		
No,	3		

C Use/access of improved water sources

C.1 What is the main source of drinking water for members of your family

C.2 What is the main source of *water for personal hygiene* for members of your family?

Coding categories	C.1	C.2	Remarks
PIPED WATER	DRINK	HYGIENE	See for the description of water sources point G.5 in the annexes.
Piped water in dwelling	11	11	
Piped water into yard/plot	12	12	(should we ask if original source is know and treatment or do we assume Q ok)
Piped water by public tap/*standpipe*	13	13	
WATER FROM OPEN WELL			Open wells have no protections against pollution by users, animals or runoff water.
Open well in dwelling	21	21	
Open well in yard/plot	22	22	
Open public well	23	23	
WATER FROM COVERED WELL OR BOREHOLE			Protected means that there is a parapet or a cover preventing the well from being polluted by its users, runoff water or animals. If in doubt ask if a pump (hand or mechanical pump) is used for the abstraction of water. If a pump is used consider the well protected. (Protection relates to water quality and not security)
Protected well in dwelling	31	31	
Protected well in yard/plot	32	32	
Protected public well	33	33	
SURFACE WATER			
River/stream	42	42	**Infiltration wells** or galleries are considered wells.
Pond/lake	43	43	Large **ground-based rainwater catchments** or hafirs will be considered in this category (pond/lake) because of their similar water qualities.
Dam	44	44	
Protected spring/ *artesian well*	41	41	Spring box with cover (to prevent direct access to water in box) is seen as protected.
Unprotected spring/ artesian well	*45*	51	
Rainwater *from roof*	51	61	Ground level rainwater-catchments are considered as ponds in this survey!
Tanker truck/*house-to-house vendor*	61	71	
Bottled water	71		Defined as industrial bottled water, with sealed top when purchased.
OTHER______________ (specify)	96	96	
We don't use a different non-drinking water source.		**99**	

C.3 How long does it take you to go there, get drinking water, and come back?

Coding categories		Go To	Remarks
MINUTES (queuing included)			Collecting time includes the time **queuing** at the water source if that occurs. Consult time chart to compare the time with daily activities (see Table 4).
On premises	996		

C.4 How many days without availability of drinking water did you have during the last seven days?

Coding categories		Go To	Remarks
Number of days drinking water was not available.			**Not available** also means that water was not collected because it was not available during normal or predictable times which made it difficult to obtain it.
water was available every day	9		

C.5 Can this drinking water source be used during the whole year, or not?

Coding categories	C.5	Go To	Remarks
Yes	1		
No	3		

C.5.a Which are the months you use this source?

January	*February*	*March*	*April*	*May*	*June*	*July*	*August*	*September*	*October*	*November*	*December*

C.6 Do you use a different source of water for personal hygiene such as washing?

Coding categories		Go To	Remarks
Yes	1		No need to explicitly ask this question again; See also question C.1 and C.2
No	3	→D	

C.7 How long does it take you to go there, get water for personal hygiene, and come back?

Coding categories		Go To	Remarks
MINUTES (includes time for queuing.			This is for the collection of water for personal hygiene (washing) if different from the drinking water. Consult time chart to compare the time with daily activities (see Table 4).
On premises	996		

C.8 Did you have a day with no availability of water for personal hygiene available last week?

Coding categories		Go To	Remarks
Number of days drinking water was not available.			**Not available** also means that water was not collected because it was not available during normal or predictable times which made it difficult to obtain it.
water was available every day	9		

C.9 Can this non-drinking water source be used during the whole year, or not?

Coding categories		Go To	Remarks
Yes	1		
No	3		

C.9.a Which are the months you use this source?

January	*February*	*March*	*April*	*May*	*June*	*July*	*August*	*September*	*October*	*November*	*December*

C.10 Do you have to pay EACH TIME you fetch drinking water?

C.11 Do you have to pay EACH TIME you fetch water for hygiene purposes?

Coding categories	C.10	C.11	Remarks
	DRINKING	HYGIENE	
Yes, I get charged for each time I collect water.	1	1	Pay-as-I carry
No, I pay a periodical fee (e.g. monthly)	3	3	Pay a rate over a period
No, I pay nothing at all	5	5	Free water supply
We do not use different water sources		9	

C.12 Do you treat the collected water before consumption? (Household water treatment only)

Coding categories		Go To	Remarks
Not treated at all	11		Water is consumed as it is collected
Sedimentation	13		Water is let to settle until it becomes clear
Boiling	15		Water is boiled for minimum one minute
Filtered with cloth	17		Water is filtered trough cloth e.g. for Guinea worm
Fine filtering	19		Ceramic drip or siphon filter, slow sand filter, etc.
Chlorination	21		Chlorine or any other chemical product is used to treat the water
Flocculation	23		Moringa seeds, Alum etc. used to speed up sedimentation
Solar disinfection	25		Done in clear bottles exposed to the sun
OTHER_____________________________ (specify)	96		

Questionnaires in relation to hygiene education and access to school sanitation.

D Hygiene education in schools

Name of the child	D.1.a Age of child in years	D.1.b Sex of Child (M/F)
Reference of school	Class	Date of today 2 0 0

D.2 Which is the most important thing to do for your health?

Coding categories		Go To	Remarks
A] Hand washing after eating	11		Read the question and all the answers out loud **twice** and allow **one** answers after the second reading.
B] Brush hair	13		
C] Cut fingernails	15		
D] Take a bath	19		
E] Have clean clothes	21		
F] Brush teeth	23		
G] Have clean ears	25		
H] Take shoes off when entering house	27		
I] Wash hands after toilet	29		

D.3 What disease is caught from excreta?

Coding categories		Go To	Remarks
Malaria	11		Read the question and all the answers out loud **twice** and allow for **min one** and **maximum two** answers after the second reading.
Diarrhoea	13		
Pneumonia	15		
Measles	17		
Cholera	19		

D.4 When do you usually wash your hands in order to keep healthy?

Coding categories		Go To	Remarks
*DO **NOT** READ OUT THE ANSWERS. MARK THOSE MENTIONED.*			You may prompt the interviewee to give **maximum three** answers.
O] Before going to the toilet	11		
P] Before handling food (cooking/eating)	13		
Q] Before cleaning child's bottom	15		
R] Before leaving the house	17		
S] After going to the toilet	21		
T] After eating	23		
U] After cleaning child's bottom	25		
OTHER (1) _______________________	96		
(2)_______________________	97		
(3) _______________________ (Specify)	98		

E Access to improved sanitation in schools

E.1 How many school boys are registered at the school?

Coding categories		Go To	Remarks
Number of school boys registered at the school:			To be asked to the director or any senior person in the school that has access to the school register.
None	99996	→ E.2	

E.2 How many school girls are registered at the school?

Coding categories		Go To	Remarks
Amount of school girls registered at the school:			
None	99996	→	

E.3 How many children are allowed per cubicle?

Coding categories		Go To	Remarks
How many children are maximum allowed per cubicle (National or regional standard).			If there is no national standard for this, use max 25 persons per cubicle.
Don't know, there is no standard.	96		

E.4 How many cubicles allowed per hand-washing point?

Coding categories		Go To	Remarks
How many cubicles are maximum allowed per hand-washing point (National or reg. standard).			If there is no national standard for this, use max 4 cubicles per washing point.
Don't know, there is no standard.	96		

E.5 What is the distance between girl's and boy's toilets

Coding categories	Go To	Remarks
Distance between girls and boys toilets in meters. (Shortest distance door to door) [ ][ ][ ] **Clearly separated** but little distance between both. 996 No separated toilets for boys and girls 999 (If no mixed school mark NO)		

E.6 How many cubicles are available for boys?

Coding categories	Go To	Remarks
Total number of cubicles available. [ ][ ][ ] Number of cubicle conform to the criteria. [ ][ ][ ] Total number of urinals available? (How many children can use it simultaneously) [ ][ ][ ] Number of urinals conform to criteria [ ][ ][ ]		Cubicles for boys or girls are only counted if they: • have a superstructure that gives enough privacy (e.g. proper door, walls etc.). ▪ are a pit latrine with floor and a small drop hole or. ▪ are flush latrine and water for flushing is available. • The toilet is clean around the drop hole/closet. • Cleansing material is available • They are no further than ±50 meters/paces away from the building. • They can be freely accessed by pupil and are not e.g. locked for the use of teachers only.

E.7 How many cubicles are available for girls?

Coding categories		Go To	Remarks

Total number of cubicles available.			Cubicles for boys or girls are only counted if they:
			• have a superstructure that gives enough privacy (e.g. proper door, walls etc.).
			  ▪ are a pit latrine with floor and a small drop hole or.
			  ▪ are flush latrine and water for flushing is available.
			• The toilet is clean around the drop hole/closet.
			• Cleansing material is available
			• They are no further than ±50 meters/paces away from the building.
			• They can be freely accessed by pupil and are not e.g. locked for the use of teachers only.

Number of cubicles conform to criteria.			

E.8 How many points are available for hand washing?

Coding categories		Go To	Remarks
Number of handwashing points available.			
A] Number of handwashing points with soap, ash or other cleaning agent available.			
B] Number of handwashing points with water available.			
C] Number of handwashing points available with a basin/or running water.			
D] No handwashing points available.	999		

General information on the survey

Basic sampling unit

For Vision 21 targets 1-3 the basic sampling unit suggested is the household.
Households are universal and relatively easy to identify. This makes them suitable to be used as basic sampling unit (BSU). However choosing the household as a basic sample unit makes the outcome a percentage in terms of households. All distinction between various types of household, such as man alone or woman and children, will be lost for analysis. This means also that gender issues will be lost.
The term "household" may be interpreted according to local conditions; however a convenient definition could be "those whose food is prepared by the same person".(Bennett S. et al., 1991). This definition might still pose a problem for the increasing amount of single person (mostly man-only) households in urban slums. It might be necessary to verify if the data obtained at household level is representative of the population before inference is made from the obtained results.
For Vision 21 targets 4-5 the basic sampling units suggested are schools and school children as discussed in the paragraphs on school indicators.

Representation of the household as basic sampling unit

Who in the household will give the information that is most representative for the household? Women have been traditionally at the 'practical' day-to-day centre of the household. They are usually involved in the collection of water, preparing the food and taking care of the children and cleanliness in and around the dwelling. It is the hygiene practices involving food preparing and child care that are most important and will have an impact on the hygiene practices taught informally to children. So women in the household seem to be the most suitable candidates to interview. They will also be the most likely person in the house at the time of the interview reducing non-respondent figures. This assumes that there is in most cases a 'normal' family constitution. In some cultures, interviewing women might not be straightforward. With so many responsibilities, women might not always be available to give information, which might increase the non-response rate in the samples. It is suggested that the person involved in the cooking, cleaning and collecting of water for the household is the person to interview if possible. It is assumed that this adult person will generally be the ***'woman of the household'***

Outcomes

"The monitoring or surveying for which the JMP was established (with a mandate from the UN Secretary General), and which the WSSCC was mandated at Iguaçu to promote, is principally "summative". Its aim is to measure a small number of quantitative indicators to determine whether targets are being achieved (Cairncross S.;2001). Summative data only are concerned with characterisation of a situation while formative information is more analytic about the situation, seeking a diagnosis of problems needing resolutions.
As the household is the BSU, the outcome of the survey is a binomial value by household for targets 1-3. These will indicate for example if the household has access to water or not. This means that all indicators we assume important and relevant for each target have to be combined until they reach a '*yes*' or a '*no*' value.
Targets 1-3 need outcomes for each household that can lead to the conclusion whether or not the household has:

1. *Good hygiene practices*; meaning that the behaviour of the household is such that it reduces the risk of pathogenic transmission.
2. *Access to adequate sanitation*; meaning that excreta are disposed of in such a way that it reduces the risk of faecal-oral transmission to its users and the environment.

3 *Access to improved water supply*; meaning that they have access to sufficient drinking water of acceptable quality as well as sufficient quantity of water for hygiene purposes.

Assessing properties to the targets for school sanitation requires us to assess whether:

4 *School child knows about hygiene* meaning that primary school children have most likely being taught about hygiene at school, but more important have gained a basic understanding on hygiene practices.

5 *School is equipped with facilities for sanitation and hand-washing*, meaning that primary schools have enough improved excreta disposal and handwashing facilities for students and staff.

F Rational for the questions and observations used in questionnaire.

A. Appropriate hygiene practices.

Section A, covers the question and observations for the indicator measuring Vision 21 Target 1, as stated below:

	Vision suggested targets for 2015	for 2025
Target 1	Universal public awareness of hygiene	Good hygiene practices universally applied

Although Vision 21 states two totally different goals, *public awareness* for the year 2015 and *good hygiene practice* for the year 2025 this survey will only concentrate on *good hygiene practice*.
For the purpose of Vision 21 we would suggest to define *good hygiene practice* by:

Day to day application of practices and habits reducing risk of faecal-oral transmission of pathogens.

This definition would focus on faecal-oral transmission as the biggest cause of hygiene-related morbidity and mortality (Curtis V. et al.;2000; WHO;1992) largely preventable through access to water, adequate sanitation and hygiene practices. The 'hygiene practice' questions and observations used have been chosen to be as independent as possible from the access to water and sanitation indicators to avoid, for example, a lack of access to water automatically appearing to have consequences for the hygiene indicator. Although this is desirable, it is difficult due to the prominent place that water supply and sanitation facilities play in the hygiene practices of the household.
This indicator has a binomial value. It indicates for each sampled household the day to day application (Yes or No) of appropriate hygiene practices. This is based on the questions and observations as mention in the questionnaire above. Each of the questions is discussed below.
In this section there are 7 questions/observations with 5 outcomes of which a minimum of 3 have to be collected, and a score is calculated from positive (good) behaviours divided by the number of outcomes collected. It is suggested that **min 2/3** or 67% should be good behaviours for the indicator to take the value 'yes'. (see Figure 8 and Table 1 on page 475)

Question

A.1 Where do you usually wash your hands?

Conclusion

In dwelling/yard/plot Needs more information. (go to question A.2)
Somewhere else
Nowhere
In regards to this question it is presumed that this is **not** a *good hygiene practice* of the household in relation to handwashing.

Origin

Question 33 of ORC Macro's DHS+ questionnaire (ORC Macro;2001).

Rationale/assumptions

The question assumes that people are washing their hands as it only asks where they wash them. Handwashing is recognised as an important hygiene behaviour that limits faecal-oral transmission of pathogens. This question is part of a series of questions which aim to determine if handwashing is likely to be practised in the household, by examining whether the attributes essential for proper handwashing are available in the household. This assumes that the practice is unlikely to benefit health if it is only practised outside the dwelling, yard, plot.
The question does not discriminate between adequate ways and times of handwashing or whether all people in the household would adhere to this practice.

Question

A.1 Where do you usually wash your hands?

Remarks/limitations

An increase of hand washing will improve health in a household. This is because of its potential to reduce the number of pathogenic organisms on our hands. In many parts of the world hand washing is not perceived as related to health (Hoque B.A. et al.;1995; Zeitlyn S.;1994). One person might use several methods of hand washing during the day, for example: rub the left hand with mud and rinse it with water after defecation; pour water over the right hand before eating; rub hands, arms legs and feet with water before prayer; or wash hands along with other parts of the body with soap in the course of a daily bath (Hoque B.A. et al.;1995). Some actions like wetting hands before eating so the food does not stick to the hands (Kamanda J.;2002) can wrongly be associated with handwashing.
The question above only aims to identify households that are unlikely to practise hand washing (coded "2 & 3") as a way of reducing faecal-oral transmission. The households with code "1" will have the potential to practise 'proper' hand washing but additional questions are necessary. The DHS manual (ORC Macro, 2001 page 33&74) mentions that *"Washing hands, especially before handling food, can protect people from getting infected with various diseases such as diarrhoea"*. There are clear indications that in reference to the F-diagram (Figure 9 on page 499) first barrier handwashing (after defecation) is more important than second barrier handwashing such as before handling food. (Curtis V. et al.;2000).

Observation

A.2 Ask to see the place and observe if the following items are present

Conclusion

When all items are present it is assumed that good hygiene practices are used in the household regarding handwashing. If any of the items are not present the opposite is assumed.

Origin

Question 34 of ORC Macro's DHS+ questionnaire (Orc Macro;2001).

Rationale/assumptions

Handwashing as spot-observation is difficult to observe during the short period of the interviewer is in the household. An alternative which more easy to observe is if attributes for proper handwashing are available in the household.

Remarks/limitations

We suggest to removed tap in answer 'A' to prevent the confusion if water or tap should be present. It is the water that should be present coming from a tap or not. We suggest to add bucket or sink to answer 'C'.
This question can only determine if it is possible for the household to practise handwashing by examining if attributes essential for appropriate handwashing are available in the household. Appropriate referring to handwashing as a way of reducing faecal-oral transmission of pathogens. The question excludes the households that are lacking essential attributes for hand washing. However the question does not allow us to determine if appropriate handwashing is practised by all members of the household in such a way and at times that it reduces faecal-oral transmission of pathogens.
An optional answer is suggested to determine the distance between the place/system for hand washing and the toilet if there is one

Question

A.3 When do you usually wash your hands in order to keep healthy?

Conclusion

A.3.B],. E] and G] are the most important times of washing hands and this in reversed importance. These three answers will be given a value +1 while all other answers will be given a value -1. The sum of the maximum three answers will determine if the answer is answered positively or negatively.

Origin

New question based on various examples tried in existing surveys.

Rationale/assumptions

This question is related to practice and not to knowledge. As mentioned before, hand washing is not always perceived relating to health (Hoque B.A. et al.;1995; Zeitlyn S.;1994). There are many different reason to wash hands (Hoque B.A. et al.;1995). To benefit health most, handwashing should be practised after defecation or after handling children's faeces. These are illustrated as first barriers in the F-diagram (Figure 9 on page 499). Handwashing before handling food or feeding children will also have health benefits but is already a secondary barrier as shown in the F-diagram on page 499.

Remarks/limitations

Various forms of this questions have been tried with usually little success. Still we think it worth to try another variation and test it. Some 'bad' answer were left in case the interviewer reads out the answers. This question examine when people claim to wash their hands. It does not indicate if this is really done neither if this does in such a way that it efficiently reduces the pathogenic load on hands. Question 495 of ORC Macro's DHS+ questionnaire (ORC Macro, 2001 page 75) is a similar question but only in relation to hand washing before food preparation.

Observation

A.4 Are there children's faeces in or around the household area, or not?

Conclusion

If **no,** this is considered a sign of good hygiene practice by the household, if **yes** the opposite is assumed.

Origin

Question taken from former draft version of this questionnaire.

Rationale/assumptions

The risk of faecal-oral transmission of pathogens will be strongly reduced if the household environment is free from (human) excreta. As it is sometimes difficult to differentiate between human and animal waste, both are considered in the question.

Remarks/limitations

Despite children's faeces having a higher pathogenic load they are considered by many people to be harmless. Interviewers will be trained to exclude obvious animal excreta in the survey e.g. goat faeces. This question links up with question A.5 which also looks at the disposal of children's faeces.

Question

A.5 What ~~*is usually*~~ *was* done to dispose of your (youngest) child's stools (diapers) ~~*when*~~ *the last time* he or she ~~*does*~~ *did* not use any toilet facility?

Conclusion

Disposed of in the toilet (answers 01,02) buried (05) and disposal in covered bin (12) are the only answers relating to good hygiene practices from the household. Rinse away (answer 06)is only considered good if adequate waste water disposal is available so we've added 'in sink/drain.

Question

A.5 What ~~*is usually*~~ *was* done to dispose of your (youngest) child's stools (diapers) ~~*when*~~ *the last time* he or she ~~*does*~~ *did* not use any toilet facility?

Origin

Question 485 of ORC Macro's DHS+ questionnaire (ORC Macro, 2001 page 71) which is similar to Question 5 form the MICS 'Water and Sanitation' module (Unicef;1999). Proposed changes to the original question and answers are in blue and italics!
No young children as answer (added) results in non-respondent for this question.

Rationale/assumptions

Despite children's faeces having a higher pathogenic load they are considered by many people to be harmless. We measure behaviour regardless of whether it is hygiene motivated or not. Asking the question with regard to children might make the question less loaded. As the disposal of the diapers is more important than their use, we suggest to omit the answer relating to diapers and suggest some other common options. We assume a proper waste collection when a covered bin is used.

Remarks/limitations

This question is only relevant for households with children still under the care of a caretaker/mother in regard to sanitation If a 'potty' or a 'diaper' is used it is the disposal of its contents that is relevant in the question although that is not expressed in the original question.
The original question addresses two issues; first the place of disposal and second the means of disposal; but does not cover all the most common combinations. Additional answer 'waste heap in yard' disposal 'in covered bin' are suggested as an addition to the standard DHS answers.
The household almost needs access to an excreta disposal facility to fulfil this condition which makes it relatively dependent to access to sanitation indicator. Even tough no access to sanitation might have a big impact on this question it was still considered worthwhile including in the questionnaire. Although burying stools is accepted as a good behaviour it needs more discipline which might not always be present. Assumption of appropriate waste collection when bin is used has to be checked.
UNICEF defines young children 0-3 years while DHS defines 0-5 years! This question is only relevant for households with children that are still under the care of a caretaker/mother in regard to sanitation (0-3 years). If this is not the case mark 99.

Question/Observation

A.6 What does the household use as a drawing mechanism for drinking water?

and

A.7 Ask to see the stored drinking water, and observe the way water is drawn from the container

Conclusion

In Question A.6 'Tap' is considered a good 'practice', while 'Hands' is considered bad practice. For 'Cup or ladle' as answer question A.7 has to be answered before a final decision can be taken. If A.7.A] is answered 'no' and A.7.B] is answered 'yes' the household is assumed to adhere to good hygiene practices in regards to these questions.

Origin

Former draft version of this questionnaire.

Question/Observation

A.6 What does the household use as a drawing mechanism for drinking water?

and

A.7 Ask to see the stored drinking water, and observe the way water is drawn from the container

Rationale/assumptions

Most water stored at home gets polluted at the household level during use. If proper drawing methods are used at the household level it is considered that the risk of faecal contamination will be reduced dramatically. If any form of container is used and (potential contaminated) hands touch the water during the drawing of the water there is a high risk of regular pollution of the water. At the same time if the container is stored in such a way that it can be contaminated this will result in similar results.

In both cases this will be considered as non appropriate health practices while tap water or other ways of abstraction will be most likely good health practices

Remarks/limitations

Need for proper training of interviewers and the adaptation of local names e.g. ladle.

School hygiene and sanitation measured at household level.

See school sanitation in point D on Hygiene education in schools and E on Access to improved sanitation in schools

Scoring mechanism:

No weights are given to the outcomes in section A as there is some indirect 'repetition' on most important issues. A minimum of three outcome have to be obtained of which 2/3 have to be positive for this indicator to be positive. In table form this would like Table 1.

A = No. of outcomes which were positive \ *Q=No. of outcome obtained in the HH survey.*	1	2	3	4	5
1	X	X	N (33%)	N (25%)	N (20%)
2	X	X	Y (67%)	N (50%)	N (40%)
3	X	X	Y (100%)	Y (75%)	N (60%)
4				Y (100%)	Y (80%)
5					Y (100%)

X results in non-response
Y/N means does/doesn't apply hygiene practices.
(%) 'percentage of good practices'.
Good Hygiene Practice.
No Good hygiene practice

Table 1: Decision model on good hygiene practices at the household.

If we would for example have 4 outcomes (one non-respondent) of which only 3 outcomes were positive in relation to hygiene practices this would result in 3 out of 4 (75%) good practices which is > 2/3 (66%) which means the household is considered to comply with good health practices, hence the green colour in the table.

Some alternative representation of the decision model are given in section G.1 on page 498.

A = No. of outcomes which were positive \ *Q=No. of outcome obtained in the HH survey.*	1	2	3	4	5
1	X	X	N (33%)	N (25%)	N (20%)
2	X	X	Y (67%)	N (50%)	N (40%)
3	X	X	Y (100%)	Y (75%)	N (60%)
4				Y (100%)	Y (80%)
5					Y (100%)

X results in non-response
Y/N means does/doesn't apply hygiene practices.
(%) 'percentage of good practices'.
Good Hygiene Practice.
No Good hygiene practice

B. Use/access to improved sanitation

Section B, covers the questions and observations in relation to indicator the for vision 21, target 2.

	Vision suggested targets for 2015	for 2025
2	Percentage of people who lack *adequate* sanitation halved	*Adequate* sanitation for everyone

In its 'Global water supply and sanitation assessment 2000' WHO / UNICEF joint monitoring programme (JMP) is no longer reporting on '*safe*' drinking water and '*adequate*' sanitation. Instead, '*improved*' water and sanitation technology types are now reported. This change in terminology reflects both the past misrepresentation, and the future uncertainty, in judging and defining services as 'safe' in terms of human health (Hunt C.;2001). For that reason we would suggest that the same terminology be used in Vision 21 targets. It is also the terminology used in the rest of this document. Sanitation in this document is used in its narrowest definition as euphemism for 'human excreta disposal'.

In the Global Assessment (Who et al.;2000) an excreta disposal system is *'improved'* when:

- It is private or shared but NOT public and if;
- It hygienically separates human excreta from human contact.
- It accessible in such a way that is likely to be used regularly.

In the Global Assessment report (Who & Unicef;2000), **shared latrines** were considered an '*improved* form of sanitation'. This was due do the use of existing databases in which it was not always possible to differentiate between shared and private latrines. According to the Joint Monitoring Program (JMP) (Henderson M.;2002) shared latrines should not be considered improved. This is because of the risk that shared latrines are more likely to be less hygienic, but also because safe use, especially in the night for women and children, will be more problematic. However in the 2nd WSSCC task force on monitoring meeting on indicators in Geneva (June 18 2002) the meeting agreed that a distinction should be made between 'improved' and 'non-improved' forms of shared toilets. Reclassifying shared latrines may not change access significantly, but it will indicate that under certain conditions these type sanitation can be forms of 'improved' sanitation.

In this document we will include shared toilets as being 'improved' forms of sanitation when:

- An 'improved' technology is used
- It is shared but not public
- Road to toilet is clear and used.
- Cubicle shows sings of recent use.
- Easy accessible day and night.
- Not more than 50m or 50 paces away.

In the title **use** and **access** are both mentioned. As only proper use (and not the access) of improved sanitation facilities will have an positive impact on the household. However for advocacy 'use' is a less powerful statement than 'access'. On the other hand in the survey it is assumed that if people would have access but are not using their latrine, because they are inappropriate in anyway, they do NOT have access. This makes that in our survey access and use are similar as we measure use as a proxy to access.

The relation between the 4 core questions and observations in relation the outcome indicator measuring target 2 is described below in Figure 2 on page 480 in a flowchart format.

Observation

B.1 What kind of toilet facilities does your household use?

Conclusion

If answers are **bucket, overhung**, **open pit or no latrine** there is no access to improved sanitation due to the type of technology used.
If a **pit latrine with floor, a VIP,** or a **flush latrine** is used than the type of latrine is improved but some questions relative to the access have to me answered.

Origin

Question 3 form the MICS 'Water and Sanitation' module (Unicef;1999) which is similar Question 23 of ORC Macro's DHS+ questionnaire (Orc Macro;2001) apart from the last word being 'use' instead of 'have'. The MICS question was preferred as 'have' in de DHS was a more restricting question as it related more to ownership.

Rationale/assumptions

Faeces in **bucket or service latrines** have to be collected regularly. It is assumed that this is done by hand and transport happens via public roads. This means that the technology does not 'hygienically separate human excreta from human contact'. **Open pit latrines** are unlikely to be hygienic and rarely used by young children because of the danger or fear of falling in. **Overhung** latrines directly pollute surface water sources, which makes them a danger in particular for people downstream in the case of a river. **Covered pit latrines** and **VIP** with a proper floor tend to be a suitable solution to hygienic excreta disposal.
Flush latrines can be an improved way of disposing of excreta if the household has access to non-drinking water so they can flush properly and if the effluent of the latrine is disposed of properly. (see also question C.7)

Remarks/limitations

Information on access to non-drinking water, with regard to flush latrines is sought elsewhere in the questionnaire. If there is no access to non-drinking water (see question C.7) flush latrines will not be considered improved sanitation. Question C.7 looks at the distance of non-drinking water if this is different from drinking water.
N.B. If emptying of bucket latrines is mechanised and the contents are disposed of properly, it might be considered as a proper disposal method.

Question

B.2 Do you share these facilities with other households?

Conclusion

If **no,** this is considered a private facility.
If **yes**, this is a shared or public facility.

Origin

Question 24 of ORC Macro's DHS+ questionnaire (Orc Macro;2001) unmodified.
For reflections on the MICS version of these question see the remarks below.

Rationale/assumptions

Toilets and latrines that are private are considered improved while public facilities are not. Shared latrines are despite the risk that they are more likely to be less hygienic and less accessible considered 'improved under certain conditions (see further).

Remarks/limitations

For UNICEF, improved type of sanitation has to be private and within dwelling, yard or compound (Question 4 from the MICS 'Water and Sanitation' module (Unicef;1999) uses the question *'Is this facility located within your dwelling, yard or compound?'*). This is a definition which is difficult to use if shared latrines will under some conditions be accepted as improved forms of sanitation. For that reason the DHS question was preferred over MICS.

Question

B.3 Do you share these facilities with other people you don't know?

Conclusion

If **yes** the latrine used is Public if **no** the latrine is shared.

Origin

Former draft version of this questionnaire.

Rationale/assumptions

This question is suggested to see to which extend people in survey depend on shared and public toilets.

Remarks/limitations

According to the JMP (Henderson M.;2002) shared latrines are not considered improved. However in the 2nd WSSCC task force on monitoring meeting on indicators in Geneva (June 18 2002) the meeting agreed that a distinction should be made between 'improved' and 'non-improved' forms of shared toilets. A shared latrine is defined as shared with people outside the household that are known to the household. A public toilet is defined as a toilet shared with people outside the household that are unknown to the household.

Question

B.4 Do you have to pay to use to the toilet EACH TIME you go?

Conclusion

The question is optional and looks only to what extent people depend on paid public services.

Origin

New optional question.

Rationale/assumptions

This optional question is suggested to see to what extent people depend on pay-a-you-use toilets. These services tend to be more expensive than services for which periodical fees are charged which reduces their accessibility.

Remarks/limitations

none

Observation

B.5 Does the toilet show signs of regular use and has good access

Conclusion

All of the answers have to be positive in order to answer this question positively. Any negative result (no-answer) results in a negative answer to this question.

Origin

Former draft version of this questionnaire.

Observation

B.5 Does the toilet show signs of regular use and has good access

Rationale/assumptions

If a locked latrine cannot be opened directly or e.g. the path to the latrine is overgrown, it is clear that other means of excreta disposal are used which for the purpose of the survey will be assumed 'not improved'

Proof of use of the toilet is probably the most powerful indicator of all in relation to access. Use of a sanitation facility indicates that the toilet probably:

- Is socially acceptable for the users;
- Provides the safety required;
- Offers the comfort needed;
- Can be run at an acceptable cost.

It will unfortunately not indicate if the excreta of the whole household (e.g. women, children, mother-in-law and babies) are deposited in the toilet.

Remarks/limitations

If the toilet is not used, this might be for a wide variety of reasons. Analysis of the causes falls outside the scope of this survey. The latrine might not fulfil all the above criteria for all potential users in the household. It will unfortunately not be possible to consider this in this survey.

Observation

B.6 Is the drop-hole/closet free from visible excreta?

Conclusion

If **no** the way the latrine is used and/or maintained does not allow it to be considered as 'improved'. If **yes** the type of latrine will have to be considered, see question B.1

Origin

Former draft version of this questionnaire.

Rationale/assumptions

If the latrine is not used in such a way that it 'hygienically separates human excreta from human contact' it can not be considered an improved means of excreta disposal. This could be due to inappropriate design.

Remarks/limitations

It will be important to standardise observations through pictures and real observation during the training of the interviewers

Decision model on household sanitation

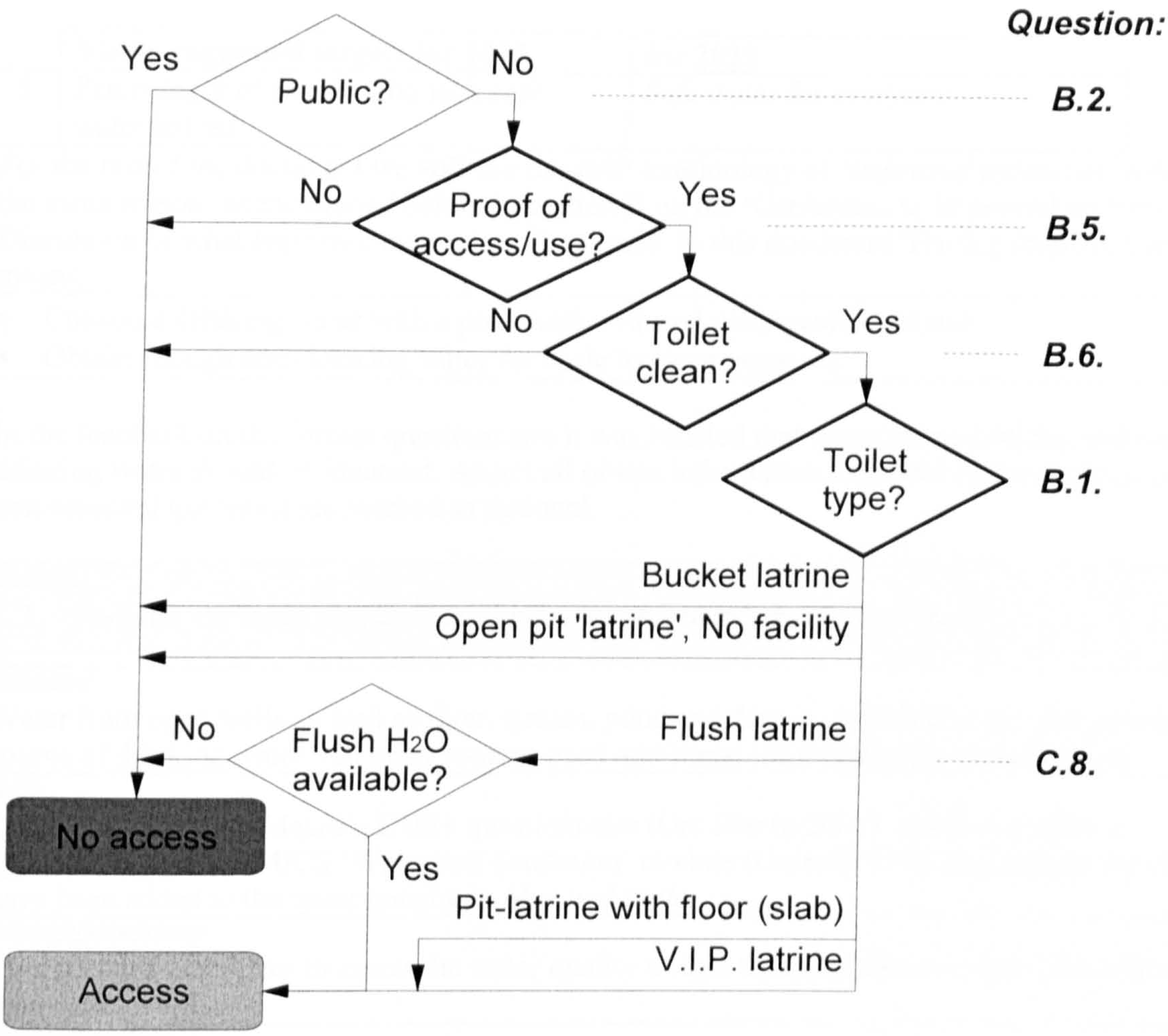


Figure 2: Decision model on household sanitation in flowchart format

C. Use/access of improved water sources

	Vision suggested targets for 2015	for 2025
3	Percentages of people who lack *safe* water halved	*Safe* water for everyone

For the rest of the document we will use the JMP terminology of '*improved* instead of '*safe'* for the same reasons as mentioned before in section B on the 'Use/access to improved sanitation'. Discussion of what *improved* means is still an issue. In this document 'Having improved water' means:

- Consume drinking water with a potentially reduced pathogenic load and
- Obtain enough non-drinking water for basic hygiene purposes.

In the feedback on the former questionnaire it was insisted that question on drinking and non drinking water should be identical. As not all of this information is needed in the decision process, non essential questions are marked as optional.

Question

C.1 What is the main source of drinking water for members of your family

Conclusion

Water from open wells as well as river, stream, pond and dam is classified as an unimproved source of drinking water. All other sources need additional information for classification.

Origin

Question 21 of ORC Macro's DHS+ questionnaire (Orc Macro;2001) which is similar to Question 1 form the MICS 'Water and Sanitation' module (Unicef;1999). Suggestions for change have been added to the questionnaire in *blue and italic.*

Rationale/assumptions

This question is a proxy to assess the water quality trough the type of source and if the source is protected.

Remarks/limitations

We have added 'piped water by' for category 13 to put more emphasis to the source of the water which for the analyses in this question is more important than its access ('public' in this case). Piped water is no guarantee of properly treated water. Some networks will distribute untreated water. Although 'spring' is NOT a source of surface water but of ground water (as is an artesian well) we left the question as it was. With 'tanker truck' we have added 'house to house vendor' this is not to confused with static vendors, term used for people selling water at public taps. There are three concepts covered in this question: the 'type' of source, its 'location/ownership' and its 'protection'. Apart from not having a clear definition on protection the set of answers become so long that breaking this question up in smaller questions might be considered.

Question

C.2 What is the main source of water for personal hygiene for members of your family

Conclusion

Most sources of fresh water are suitable for hygiene purposes. This question is optional and does not contribute to the 'access to water' indicator.

Question

C.2 What is the main source of *water for personal hygiene* for members of your family

Origin

Similar to Question 21 of ORC Macro's DHS+ questionnaire (Orc Macro;2001) which is similar to Question 1 form the MICS 'Water and Sanitation' module (Unicef;1999). Suggestions for change have been added to the questionnaire in *blue and italic*.

Rationale/assumptions

Most health benefits are obtained by hygiene practices like washing and not by improved water quality. The GA2000 assumes that bottled water will be too expensive and therefore will not be used for washing. The assumption in the analysis is that in such cases, bottled water is the only source of water. In the DHS[1] data set 1996 of the Dominican Republic for example, 18% (n=8830) of the households stated that they used bottled water as drinking water source. Of the households using bottled water, 93% (n=1599) have an indoor or outdoor piped connection. This shows that assumptions have to be checked and access to non-drinking water needs to be assessed in order to make an assessment of drinking water provision.
The main differences between drinking and non-drinking water are the quality and quantity needed. For drinking one would hope to have access to a better water quality source but relatively low quantities are required, while for non-drinking purposes, quantity and convenience would be generally more important than the quality. Only if both conditions (access to drinking and non-drinking water) are fulfilled will the Vision 21 access to water criteria be fulfilled.
For this reason we split the questions for the access to water indicator into questions for drinking and for non-drinking water. Water for drinking and hygiene will most of the time be the same.

Remarks/limitations

Non-drinking water is the water used for washing but excludes water uses such as irrigation and cattle.

Question/Observation

C.3 How long does it take you to go there, get drinking water, and come back?

Conclusion

If collection time is **more than 30 minutes** than there is **no** access in regards to drinking water.

Origin

Question 22 of ORC Macro's DHS+ questionnaire (Orc Macro;2001).
Question 2 form the MICS 'Water and Sanitation' module (Unicef;1999).

Rationale/assumptions

It has been shown (Cairncross S. *et al.*;1993) that if between 3 to 30 min time is needed (round trip, including queuing) for water collection the amount of water collected varies little with the distance. If more time is needed the amount of water collected drops (Figure 3).
The time we want to measure in this question is the time spent going and coming back from the source plus the time spent queuing and pumping. Activities such as socialising (unless done while queuing) and washing cloths at the source are to be excluded from the time measured.
The assumptions are:

- People are good in estimating time. See also Table 4.
- Difference in altitude between household and source or difficult paths will partially be represented by the extra time needed to collect the water;
- Effort to abstract water such as pumping will be represented in the water collection time.

[1] Demographic Health Survey (DHS III) by ORC Macro[SM] for U.S.A.I.D at http://www.measuredhs.com/.

Question/Observation

C.3 How long does it take you to go there, get drinking water, and come back?

Remarks/limitations

There two possible situations in the collection of water. One is that the drinking and non-drinking source is the same, and the other that households use different sources for different applications. For drinking water the water quality is the most important factor, the quantities needed will be less and so will be the effort if it has to be carried home. On the other hand for non-drinking water the quality is less of an issue but the amounts that have to be transported will be larger and the effort that comes with this activity. To restrict the amount of questions, it would be good to enquire about the source of the drinking water and to ask for the distance or time needed for the collection of the non-drinking water. It assumes that the effort of collecting drinking water from another source is acceptable to the household (not seen as a constraint). This makes the collection time/distance to the drinking water source less relevant for drinking water than the for non-drinking water and will for that reason this question is considered optional.

Question

C.4 How many days without availability of drinking water did you have during the last seven days?

Conclusion

If **yes** this source will be considered an intermittent source.

Origin

Modified question from former draft questionnaire.

Rationale/assumptions

This is the rational of this question in terms of drink water quality. For the rational relating to water quantity see comments on question C.8. No water distribution network is free from leaks, but as long as the network is under pressure the chance of pollution getting into the network is low. If however the water pressure in the networks drops, pollution can get into the distribution network. If the source becomes intermittent the risk of pollution increases with each cycle of intermitted pressure in the network. For that reason intermittent piped water sources are not considered improved. If there is proof that the quality is influenced by the intermittence the question can answered yes or omitted.

While the original question was in relation to daily intermittence the question has been changed to weekly intermittence.

Remarks/limitations

The main question is what is more representative for intermittence, daily or weekly variations?

Question

C.5 Can this drinking water source be used during the whole year, or not?

Conclusion

There are no conclusions in regards to access to improved water sources (hence optional question) but it gives an idea on the importance of seasonality.

Origin

New (optional) question

Rationale/assumptions

In the former discussion document and subsequent discussion in Geneva (18/06/2002) on the former version of this document it was acknowledged that seasonality is a problem in water supply. It was also recognised that it is difficult to include it in the questionnaire in an easy way.

Remarks/limitations

An alternative question could be question C.5.a "*Which are the months you use this source?*"

Question
C.5 Can this drinking water source be used during the whole year, or not?

January	*February*	*March*	*April*	*May*	*June*	*July*	*August*	*September*	*October*	*November*	*December*
This question would give timely information on the use of the actual drinking water source.											

Question
C.6 Do you use a different source of water for personal hygiene such as washing?

Conclusion
If '**no**' sources like 'tanker', 'house to house vendor' and 'bottled water' will **not** be considered 'improved' water sources. If '**yes**' they will be assumed 'improved' water sources. For other sources, other information will be needed. (see also Table 3 on page 500)
Origin
Question from former draft questionnaire.
Rationale/assumptions
Water that is delivered by tanker or vendor is assumed to be more expensive. If it is the only source of water the elevated cost will likely reduce the amount of water purchased for hygiene practices. This makes tanker, vendor and bottled water not an 'improved' water source for households who have no alternative non-drinking water source. If there is an alternative for non-drinking water is assumed that they purchase this more expensive water because of its 'improved' quality.
Remarks/limitations
None

Question
C.7 How long does it take you to go there, get water for personal hygiene, and come back?

Conclusion
If collection time is **more than 30 minutes** than there is **no** access in regards to drinking water.
Origin
Question 22 of ORC Macro's DHS+ questionnaire (Orc Macro;2001). Question 2 form the MICS 'Water and Sanitation' module (Unicef;1999).
Rationale/assumptions
See rationale and assumptions for question C.3.
Remarks/limitations
See also remarks/limitations for question C.3.

Question
C.8 Did you have a day with no availability of water for personal hygiene available last week?

Conclusion
If **yes** this source will be considered an intermittent source.
Origin
Modified question from former draft questionnaire.

Question

C.8 Did you have a day with no availability of water for personal hygiene available last week?

Rationale/assumptions

This is the rational of this question in terms of drink water quality. For the rational relating to water quantity see comments on question C.8. No water distribution network is free from leaks, but as long as the network is under pressure the chance of pollution getting into the network is low. If however the water pressure in the networks varies, pollution can get into the distribution network trough different processes. If the source becomes intermittent the risk of pollution increases with each cycle of intermitted pressure in the network. For that reason intermittent piped water sources are not considered improved. If there is proof that the quality is influenced by the intermittence the question can answered yes or omitted.
While the original question was in relation to daily intermittence the question has been changed to weekly intermittence.

Remarks/limitations

Like mentioned before the question is what will be more representative for intermittence, daily or weekly variations of water supply?

Question

C.9 Can this non-drinking water source be used during the whole year, or not?

Conclusion

There are no conclusions in regards to access to improved water sources (hence optional question) but it gives an idea on the importance of seasonality.

Origin

New (optional) question

Rationale/assumptions

In the former discussion document and subsequent discussion in Geneva (18/06/2002) on the former version of this document it was acknowledged that seasonality is a problem in water supply. It was also recognised that it is difficult to include it in the questionnaire in an easy way.

Remarks/limitations

An alternative question could be question C.9.a "Which are the months you use this source?"

January	*February*	*March*	*April*	*May*	*June*	*July*	*August*	*September*	*October*	*November*	*December*

This question would give timely information on the use of the actual drinking water source.

Question

C.10 Do you have to pay EACH TIME you fetch drinking water?

C.11 Do you have to pay EACH TIME you fetch water for hygiene purposes?

Conclusion

If pay-as-you-carry then 'no-access' to the source will not assumed.

Origin

New proposed question

Rationale/assumptions

Although the cost of water is a important factor in access there it is difficult to set standards or evaluate cost for water as it should be evaluated in relation to income. It is however well documented that the cost of pay-as-you-carry services are significantly higher compared to other financial payment structures (Adrianzen B.T. *et al.*;1974; World Bank;1995; Zaroff B. *et al.*;1984). The higher cost will not only reduce accessibility but will also reduce the amount of water purchased for personal hygiene.

Question

C.10 Do you have to pay EACH TIME you fetch drinking water?

C.11 Do you have to pay EACH TIME you fetch water for hygiene purposes?

Remarks/limitations

Although the cost of pay-as-you-carry is much higher it is not always the case that the cost is unacceptable high (Whittington D. *et al.*;1989).

Question

C.12 Do you treat the collected water before consumption? (Household water treatment only)

Conclusion

Water treatments like boiling, 'fine' filtering, chlorination and flocculation could be considered to lead to improved water quality if applied correctly.

Origin

New optional question

Rationale/assumptions

If people can treat their water on a household level adequately they obtain an 'improved' quality of water although it is not the source that is improved. It is however difficult to judge if household water treatment is done adequately. This why it is not part of the core questionnaire.

Remarks/limitations

The efficiency of chlorination will depend strongly on the turbidity and the ph of the water treated. Reducing pathogens in water treated will only be achieved by flocculation if the clarified water is separated from the flocs directly after flocculation. For boiling there is a minimum boiling time and for chlorination the turbidity and pH should be adequate for efficient treatment. Home treatment of water is rarely done reliably. In that respect it is difficult to consider that home treatment leads to access to improved water. It could be considered when water quality measurement can be done on household level as the research done by WEDC for WHO.

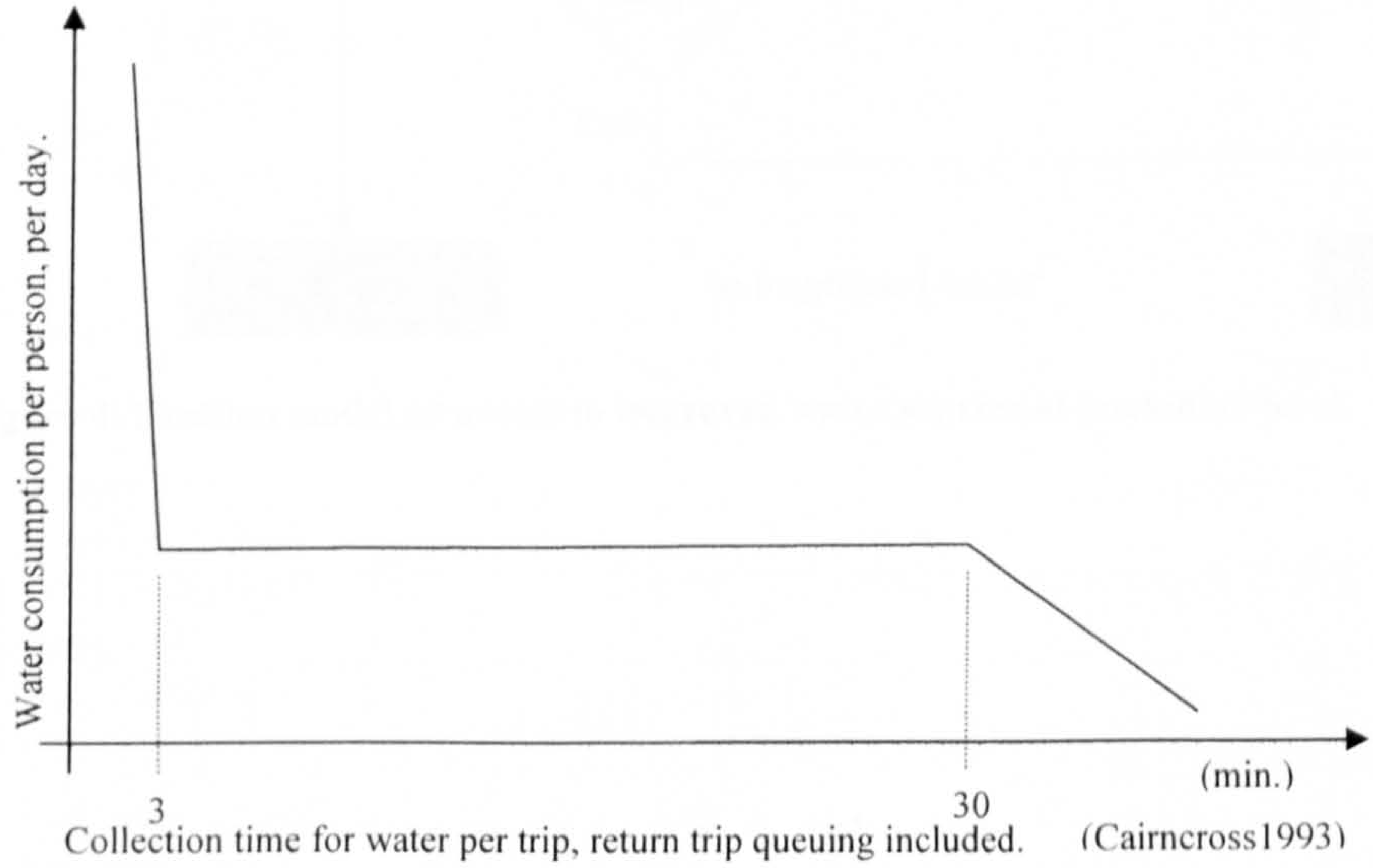


Figure 3: Water consumption in relation to water collection time.

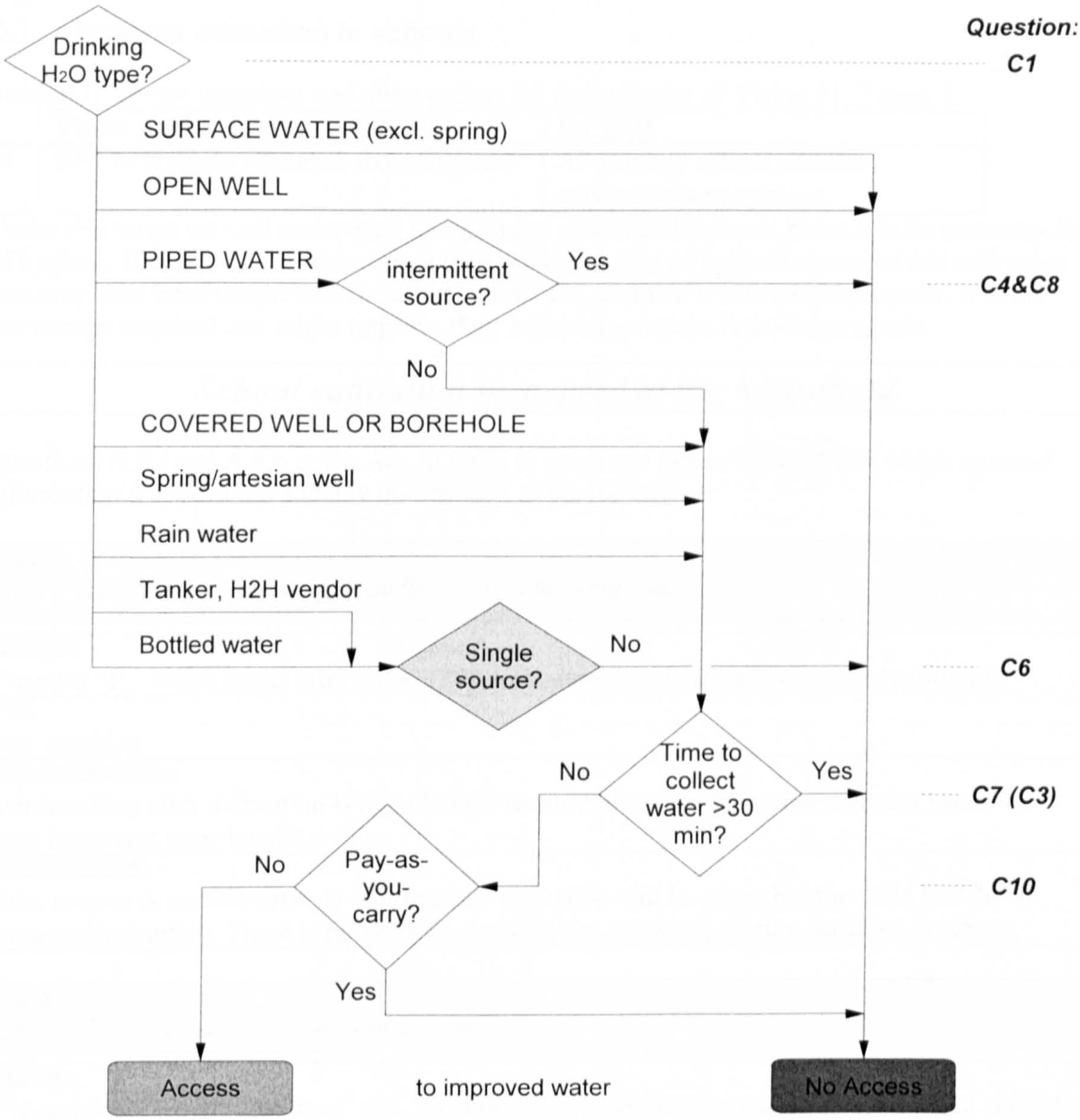


Figure 4: Decision model on access to improved water sources at household level.

D. Hygiene education in schools

Section D, covers questions and observations for the indicator of Vision 21, Target 4:

	Vision suggested targets for 2015	for 2025
4	80% of children educated about hygiene	All primary school children educated about hygiene.

Under this target we will understand that primary school children can prove a basic understanding of hygiene. If children can demonstrate their understanding of hygiene practices this will prove that they have been taught this, most likely at school, and that it was taught properly. It is the knowledge acquired that might improve their behaviour, not the knowledge taught.

School sanitation measured at the household.

Questions A.8.a and A.8.b cover Age of child in years and Sex of Child (M/F) which optional information that does not add any information to the indicator.

Question

A.8.c Which is the most important thing to do for your health?

Conclusion

If answer 'I', 'Wash hands after toilet' (29) is selected the question is answered positively.

Origin

New question

Rationale/assumptions

Handwashing after defecation is regarded the most important hygiene practice and hence the most important to be taught.

Remarks/limitations

If the answer is correct not only will hygiene education will be given but the child has shown some understanding. There is however no proof of the knowledge being acquired at school.

Question

A.8.d What disease is caught from excreta?

Conclusion

If 'diarrhoea' (13) or 'diarrhoea' and 'cholera' (19) are chosen the question is answered correctly. If any of the other chooses is selected this question is answered negatively.

Origin

New question.

Rationale/assumptions

Health education is likely to make a causal links between practice and common and well know diseases.

Remarks/limitations

None.

Question

A.8.e When do you usually wash your hands?

Conclusion

See conclusion of question A.3 for details as the two are identical.

Origin

See 'origin' of question A.3.

Question
A.8.e When do you usually wash your hands?

Rationale/assumptions
See rational/assumptions of question A.3.
Remarks/limitations
See remarks/limitations of question A.3.

Question/Observation
A.8.l Does the teacher send you home if you arrive at school looking dirty?

Conclusion
No conclusion, optional question.
Origin
New question.
Rationale/assumptions
This question indicate how much the school is concerned with hygiene and act on the issue. Asking question on school sanitation at the household level is a good idea as the children are likely to be less influenced by their school environment in answering questions.
Remarks/limitations
There might be a problem with non-respondents during the day or during school holidays. Another problem is to determine enumerator and denominator in relation to Vision 21 indicators and targets. If stratifying the schoolchildren in the household along primary school can also result in unrepresentative sample sizes.

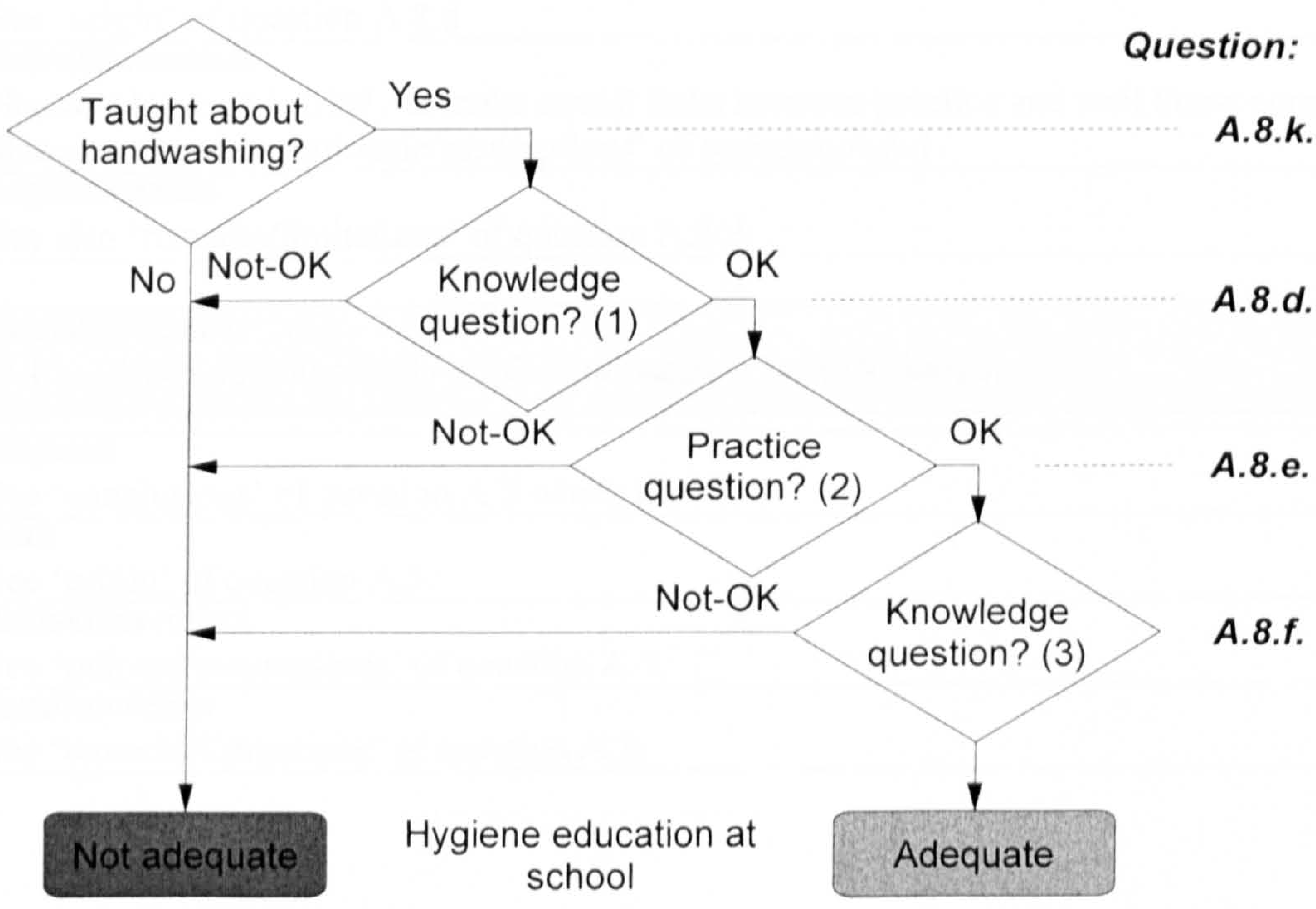


Figure 5: Decision model on hygiene education in schools based on the household survey.

School sanitation measured at School

Questions in D1 cover various optional information of which D.1.a Age of child in years, D.1.b Sex of Child (M/F)

Question/Observation
D.2 Which is the most important thing to do for your health?

Conclusion
See conclusions of question A.8.c as it is identical.
Origin
See origin of question A.8.c.
Rationale/assumptions
Handwashing after defecation is regarded the most important hygiene practice and hence the most important to be taught. See 'rational/assumptions' of question A.8.c
Remarks/limitations
See 'remarks/limitations' of question A.8.c

Question/Observation
D.3 What disease is caught from excreta?

Conclusion
See question A.8.d which identical.
Origin
See 'origin' of question A.8.d
Rationale/assumptions
Health education is likely to make causal links between practice and well know common diseases. See also 'rationale/assumptions' of question A.8.d
Remarks/limitations
See also 'remarks/limitations' of question A.8.d.

Question/Observation
D.4 When do you usually wash your hands in order to keep healthy?

Conclusion
See 'conclusions' of question A.3 which identical.
Origin
See 'origin' of question A.3.
Rationale/assumptions
See 'rational/assumptions' of question A.3.
Remarks/limitations
See 'remarks/limitations' of question A.3.

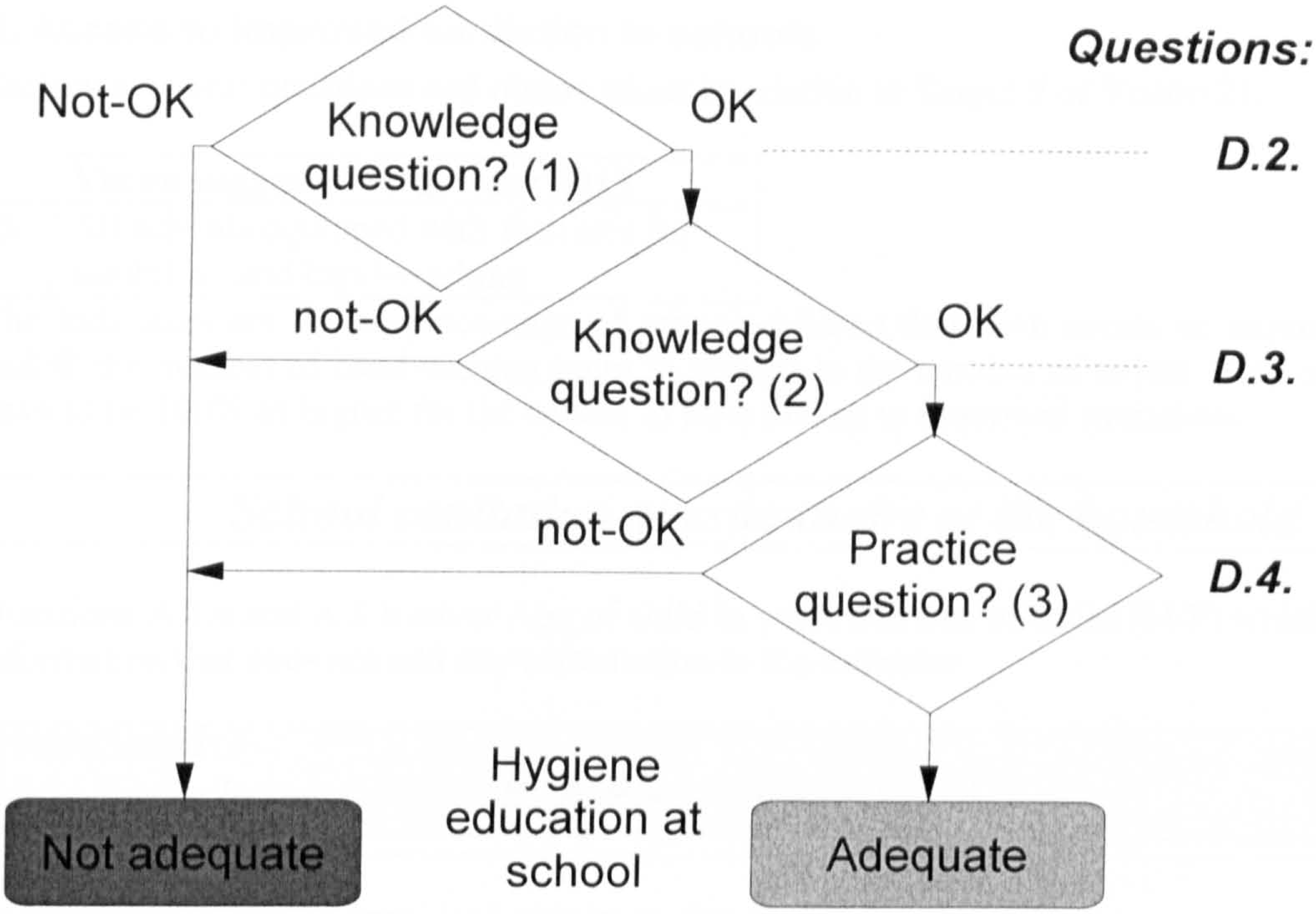


Figure 6: Decision model on hygiene education in schools based on the school survey.

E. Access to improved sanitation in schools

Section E covers questions and observations in relation to Target 5 of Vision 21.

	Vision suggested targets for 2015
5	All schools equipped with facilities for sanitation and hand-washing

The indicators are ① the percentage of school children that have access to improved sanitation, and ② the number of handwashing point in regards to the number of toilets. Both of the outcomes have to be 100% or higher for the school to have access to improved sanitation.

School sanitation questionnaire at the household

Questions A.8.a and A.8.b cover Age of child in years and Sex of Child (M/F) which optional information that does not add any information to the indicator.

Question/Observation
A.8.f Where do your friends defecate when they are at school?

Conclusion
Only school toilets is a 'positive' answer on this question.
Origin
New question.
Rationale/assumptions
This question aims to see if schoolchildren use toilets at school as a proxy to access. Relating the question to 'friends' instead of the interviewee makes the question less loaded.
Remarks/limitations
This question does not imply that school toilets are available or not but is based on the assumption that if enough suitable school toilets are available to the students they would be used.

Question/Observation
A.8.g Do you have to queue most times when you want to use the toilets at your school?

Conclusion
If **no** it will assumed that that there will be enough toilets available at the school.
Origin
New .question.
Rationale/assumptions
If there are improved toilets available and there are queues for their use that there are not enough facilities available. Although the opposite is also assumed it less likely to be true.
Remarks/limitations
The biggest assumption is that if an improved sanitation technology is used that the students use them. But if there are not enough toilets available it is more likely that the students look for alternatives instead of queuing.

Question/Observation
A.8.h Are the toilets for boys and girls separated?

Conclusion
If the school is mixed and has no separated latrine the school provides no access to sanitation for girls.

Question/Observation
A.8.h Are the toilets for boys and girls separated?

Origin
New question.
Rationale/assumptions
Often girls do not benefit from primary education because no adequate sanitation facilities are provided.
Remarks/limitations
Lack of facilities and poor hygiene affect both girls and boys, although poor sanitation conditions at school have a stronger negative impact on girls. All girls should have access to safe, clean, separate and private sanitation facilities in their schools. If there are no latrines and hand-washing facilities at school or if they are in a poor state of repair, then many children would rather not attend than use the alternatives. In particular, girls who are old enough to menstruate need to have adequate facilities at school, separate from those of boys. If they don't, they may miss school that week and find it hard to catch up, which makes them more likely to drop out of school altogether. Many children, again mainly girls, miss out on time at school because they are having to walk long distances in order to fetch water. Also in schools, when the schoolteacher sends children to fetch water, it is predominantly girls who are sent.

Question/Observation
A.8.i Is there a place for handwashing at your school?

Conclusion
Apart from answer 1 all other answers lead to non-presence of adequate handwashing facilities at the school. For solution 1 it only provides a partial answer to the presence of adequate handwashing facilities and more question will have to be asked.
Origin
New question.
Rationale/assumptions
Handwashing after the use of a toilet is an integral part of first level barrier against faecal-oral transmission of pathogens and mentioned in Vision target 5
Remarks/limitations
None.

Question/Observation
A.8.j Do the handwashing facilities have: ….

Conclusion
If all attribute are present handwashing facilities it will be assumed that school provides access to handwashing facilities.
Origin
New question.
Rationale/assumptions
For handwashing to be a efficient barrier against faecal-oral transmission the mentioned items should be present.
Remarks/limitations
The question, if answered correctly, will only indicate that appropriate handwashing is made possible by the school but does not say anything on the day to day practice.

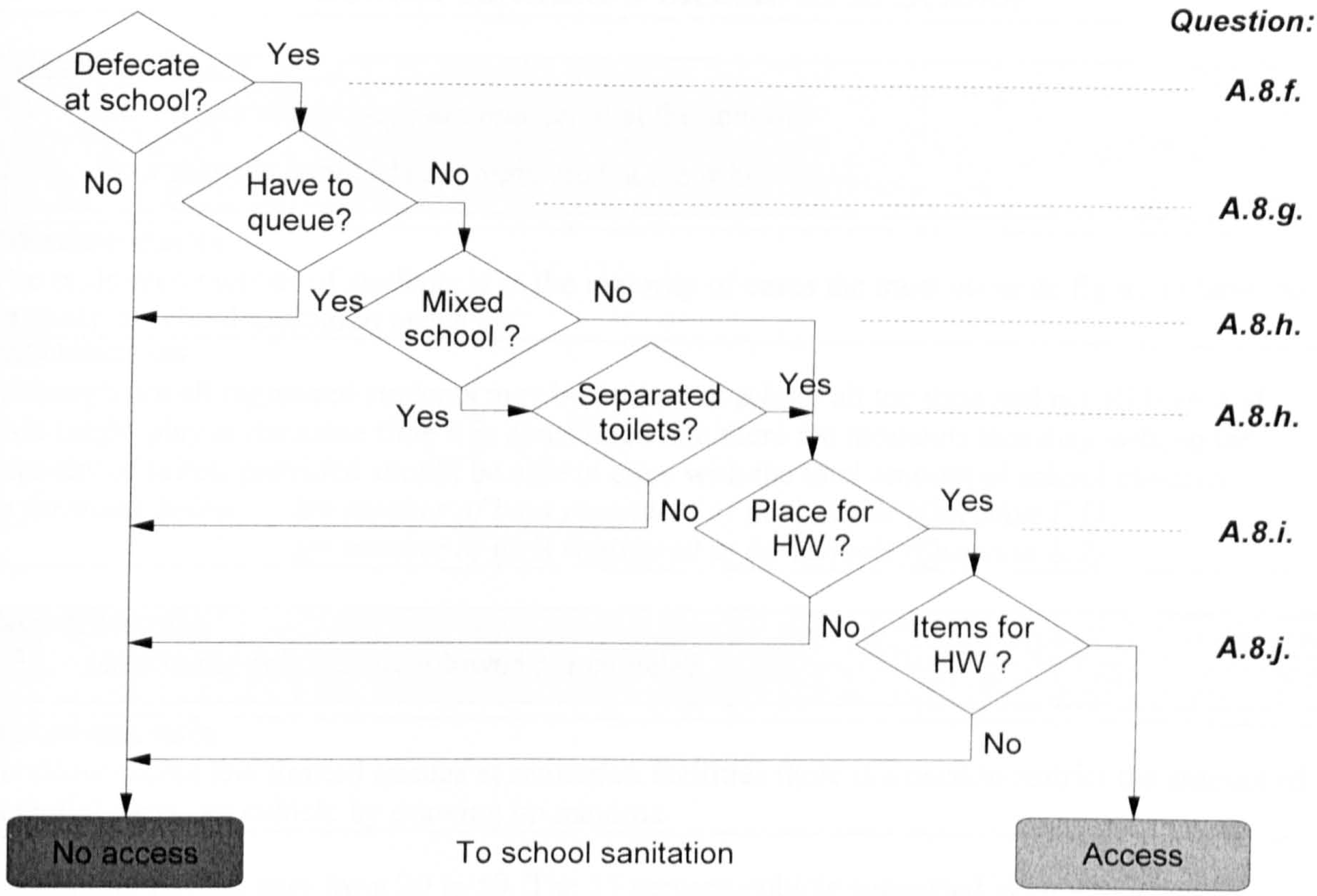


Figure 7: Decision model on hygiene education in schools based on the household survey.

School sanitation measured at School

Question/Observation

E.1 How many school boys are registered at the school?

E.2 How many school girls are registered at the school?

Rationale/assumptions

The registered number of students is in the majority of cases the most accurate figure to base the capacity of school sanitation needs on.

Remarks/limitations

Although not all registered students may be present at school all the time and not all boys and girls might play at the same time it is considered that there are moments that they will, so the capacity of toilets provided should be able to cope with the total amount of school children.

In formulas below: *b= number of boys registered at the schools (Question E.1)*
g= number of girls registered at the schools (Question E.2)

Question/Observation

E.3 How many children are allowed per cubicle?

Rationale/assumptions

To allow access and limited queues at sanitation facilities there is a need to restrict the amount of potential users per cubicle by drawing up maxima.

Remarks/limitations

In literature figures vary from 20 to 50. The 25 persons/cubicle suggested is only as a base of discussion as it is not scientific or experienced based.
The relation between school children and cubicle is not necessary linear, as in case of high number of children higher quota children per cubicle is acceptable.

In formulas below: *q= max number of school children allowed per cubicle (Question E.3)*

Question/Observation

E.4 How many cubicles allowed per hand-washing point?

Rationale/assumptions

To give access and increase the likelihood of the use of the handwashing facilities enough have to be available.

Remarks/limitations

In literature figures vary widely. The 4 cubicles per handwashing point suggested when no standards are available is only as a base of discussion as it is not scientific or experienced based

Question/Observation

E.5 What is the distance between girl's and boy's toilets

Rationale/assumptions

If there is a clear separation between both facilities this will sufficient although if there are national standards this will have to be respected.

Remarks/limitations

None

Question/Observation

E.6 How many cubicles are available for boys?

E.7 How many cubicles are available for girls?

Rationale/assumptions

By calculating the ratio of 'available cubicles' per 'number of cubicles considered necessary' it is possible to calculate the coverage in percentages.

Remarks/limitations

Cubicles for boys or girls are only counted if they:

- have a superstructure that gives enough privacy (e.g. proper door, walls etc.).
  - are a pit latrine with floor and a small drop hole or.
  - are flush latrine and water for flushing is available.
- The toilet is clean around the drop hole/closet.

They are no further than ±50** meters/paces away from the building.

For boys urinals can only represent a maximum of 50% of the available capacity. All above should be neglected in the following calculations.

If there is no clear separation between the girls and boys toilets (Question E.5) the answer on question E.7 becomes zero.

Question/Observation

E.8 How many points are available for hand washing?

Rationale/assumptions

See also rational/assumptions in question E.4. All these attribute should be present to make these points suitable for handwashing that allows a reduction of the pathogenic load on hands.

Remarks/limitations

None.

	Answers		Question
b=		Boys	E.1
g=		Girls	E.2
q=		Pers./toilet	E.3
tag		toilets	E.7
tab		toilets	E.6

If there no separate toilets for girls (question E.5) mark **tag**=0. If not mark the amount of latrines available to girls, given the following definition in the table.

Coverage for girls **cg**	$cg = \frac{tag.q}{g} = \frac{\quad . \quad}{\quad} = \quad\%$	If the percentage is higher than 100% e.g. 120% note down 100% as coverage.
Coverage for boys **cb**	$cb = \frac{tab.q}{b} = \frac{\quad . \quad}{\quad} = \quad\%$	

These two percentages have to be added up and weighted in relation to the amount of boys and girls in the school. The total coverage then becomes:

Total coverage **ct**	$ct = \frac{cg.g}{g+b} + \frac{cb.b}{g+b} = \frac{\quad . \quad}{\quad + \quad} + \frac{\quad . \quad}{\quad + \quad} = \quad\%$

** Here the distances vary as well in literature but 50 meters was a commonly used value. This figure is up for discussion.

If this result is below 100% than the school has NO access to improved sanitation. We will however use the percentage of school children having access to sanitation by weighing the result of this and other schools with the amount of children registered in every school.

Access to handwashing facilities.

	Answers		Question
wa=		handwashing points available	E.8
r=		max. number cubicles allowed per washing point	E.2

According to vision 21, Target 5, is access to handwashing facilities included in target 5.

If ***r*** is the max. number cubicles allowed per washing point (Question E.4) and ***wa*** is the number of washing points available then the coverage is:

$$= \frac{r.wa}{tag + tab} = \frac{\quad . \quad}{\quad + \quad} = \qquad \%$$

If this value is below 100% the school does not have sufficient access to improved sanitation or we use the percentage as being representative for whole of the school.

The lowest value either access to sanitation or hand washing will be used as representative for the school and has to mentioned together with the total amount of registered school children (boys + girls; Question E.1 + E.2) in brackets.

G Annexes

G.1 Alternative decision models for sec. A on 'Appropriate hygiene practices.'

Questions	Outcomes
A1 +A2	1st
A3	2nd
A4	3rd
A5	4th
A6 +A7	5th

If	Outcomes of which		Or more are considered bad practice then	*Indicator*	If not	*Indicator*
1		0		Non response!		Non response!
2		0				
3		1		neg.		pos.
4		2		neg.		pos.
5		3		neg.		pos.

Non response means that there were to many questions without an outcome to make a decision.

The flowchart presentation is shown below but does not seem to be the best presentation for this decision model. Q and A are like counters for question (Q) and for positive answers (A). If an question is answered Q becomes Q+1, if the question is answered correctly a becomes A+1 if not A stays the same as before A + 0.

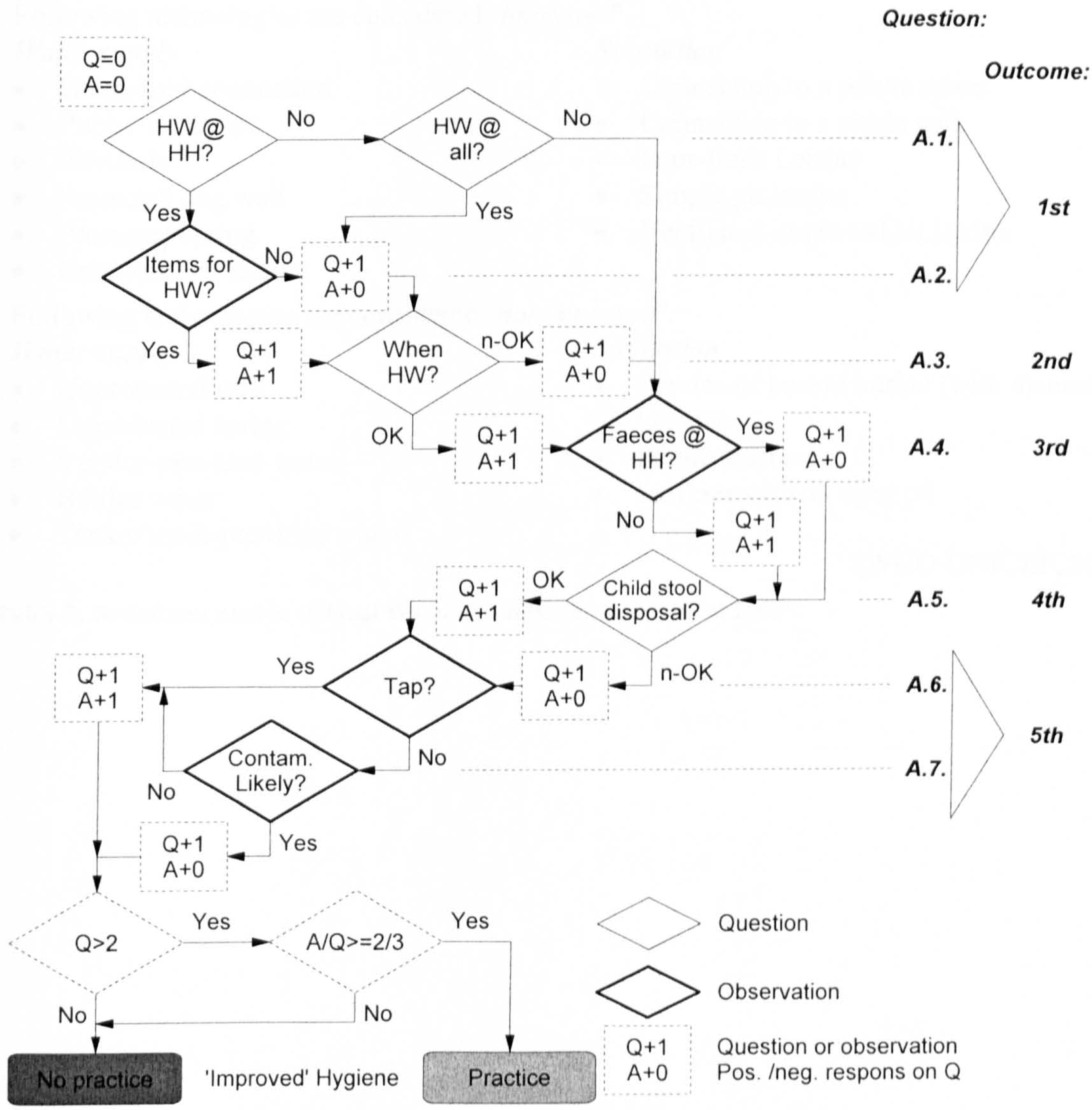


Figure 8: Decision model on good hygiene practices at the household in flowchart format.

G.2 Faecal-oral transmission routes

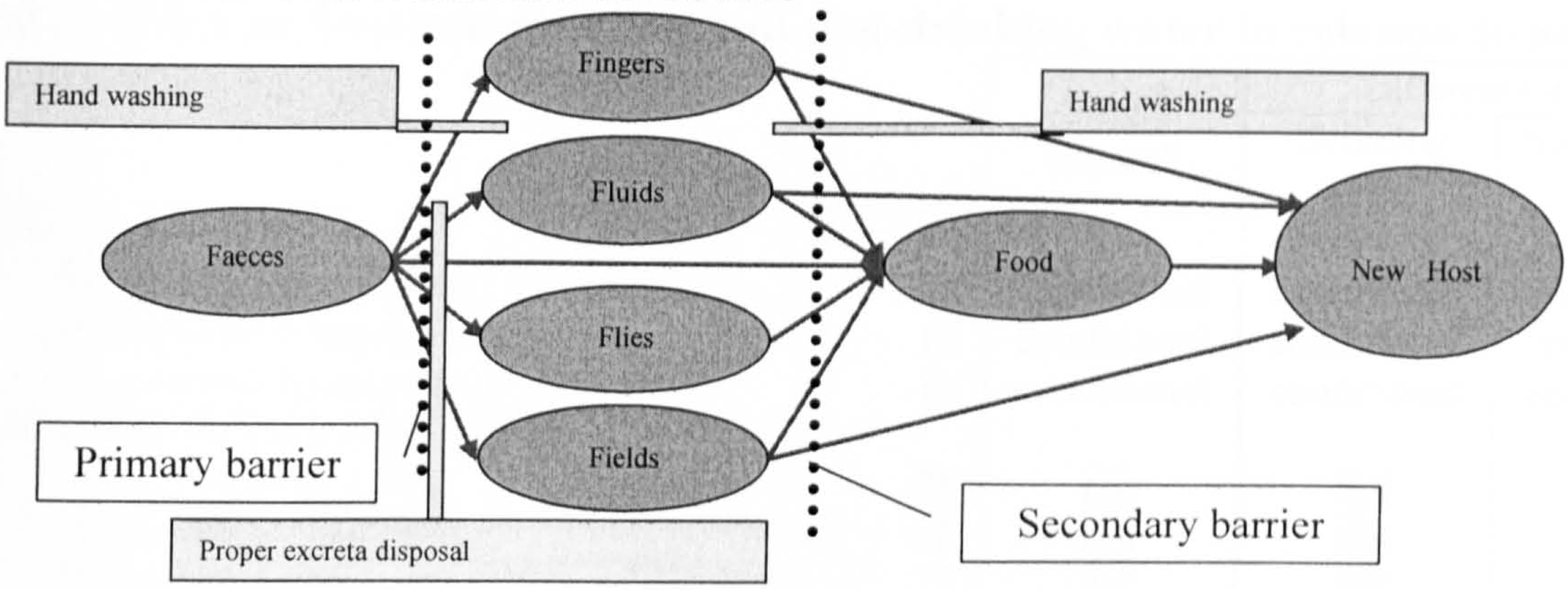


Figure 9: F-diagram of faecal-oral transmission routes

Following technologies are considered '*improved*'.

Water supply
- Household connection
- Public standpipe
- Borehole
- Protected dug well
- Protected spring
- Rainwater collection

Sanitation
- Connection to a public sewer
- Connection to a septic tank
- Pour-flush Latrine
- Simple pit latrine
- Ventilated improved pit latrine

Following technologies are considered *'not improved'*.

Water supply
- Unprotected well
- Unprotected spring
- Vendor-provided water
- Bottles water
- Tanker truck-provided water

Sanitation
- Service or bucket latrine (with manual labour)
- Public latrines
- Latrines with an open pit

(WHO-UNICEF, 2000)

Table 2: Definitions used in 'Global Water & Sanitation Assessment 2000'

G.3 Relation between drinking and non-drinking water in relation to access.

		Single source*	Different sources	
			Drinking water*	Non drinking water*
PIPED WATER				
Piped water in dwelling	11	conditional	conditional	conditional
Piped water into yard/plot	12	conditional	conditional	conditional
Piped water by public tab	13	conditional	conditional	conditional
WATER FROM OPEN WELL				
Open well in dwelling	21	not	not	not
Open well in yard/plot	22	not	not	not
Open public well	23	not	not	not
WATER FROM COVERED WELL OR BOREHOLE				
Protected well in dwelling	31	improved	improved	improved
Protected well in yard/plot	32	improved	improved	improved
Protected public well	33	conditional	conditional	conditional
SURFACE WATER				
Spring	41	conditional	improved	conditional
River/stream	42	not	not	conditional
Pond/lake	43	not	not	conditional
Dam	44	not	not	conditional
Rainwater	51	improved	improved	improved
Tanker truck/house to house vendor	61	not	improved	conditional
Bottled water	71	not	improved	not

Table 3 : Suggested classification of different water sources

G.4 Time table

To have a better idea of time, a list could be made listing day-to-day activities and their typical times such as the example below.
Question **Error! Reference source not found.** and **Error! Reference source not found.** relates to events in the last two weeks. To reduce recall bias a list of important events around the two week barrier could be drawn up.

Activity	**Time**
Frying chips	10 min
Boiling Ugali	30 min
Main events one week and to weeks ago	**Days ago**

Table 4: Estimated time for daily activities

* For drinking water the source is assessed on its likely quality. For non-drinking, which in this case covers mainly water for personal hygiene, water the source is assessed on the quantity people are likely to use. If there is only one source used drinking and non drinking water will be the same and results as in the last column.

G.5 Brief description of water sources

Surface water

Surface waters include lakes ponds, rivers, streams, canals, dams. They tend to be the most polluted and are not considered as an improved water source for drinking water if they not treated before drinking. Large ground-based rainwater cathments or hafirs will be considered in this category because of their water quality.

Spring water and artesian well

This is a special form of ground water. Water from a spring is considered as an improved water source if a covered spring box protects the spring. Getting the right information of the spring protection at the household level will be difficult which makes this type of information unreliable. The diagnostic question to identify whether the water point is a spring is to ask whether the source has continuous flow. To check if it is protected is to ask if any concrete was used around the source or the water comes from a pipe or channel. If not protected this source will not be considered improved.

Ground water

Ground water sources like wells and boreholes (Hand or machine made) are generally sources of good drinking water quality needing no treatment. The main potential source of pollution is through the same hole the water is abstracted. This can be due to the abstraction method or from run-off water if no proper protection is provided. Again this is difficult to assess at household level. There are some ways in which water collection is more likely to pollute the water source than others. For that reason it is suggested that if groundwater is pumped by hand or mechanically, it is considered an improved water source. If water is collected by bucket, bag or other recipient, it is not considered to be an improved water source unless the water is treated for drinking. Infiltration wells will for our purpose be considered as wells, as they will provide similar qualities of water if they are properly built.

Rainwater

Household rainwater (roof) catchments are considered an improved water source. Large ground based rainwater catchments are not considered improved, as was mentioned above.

Piped or tap water

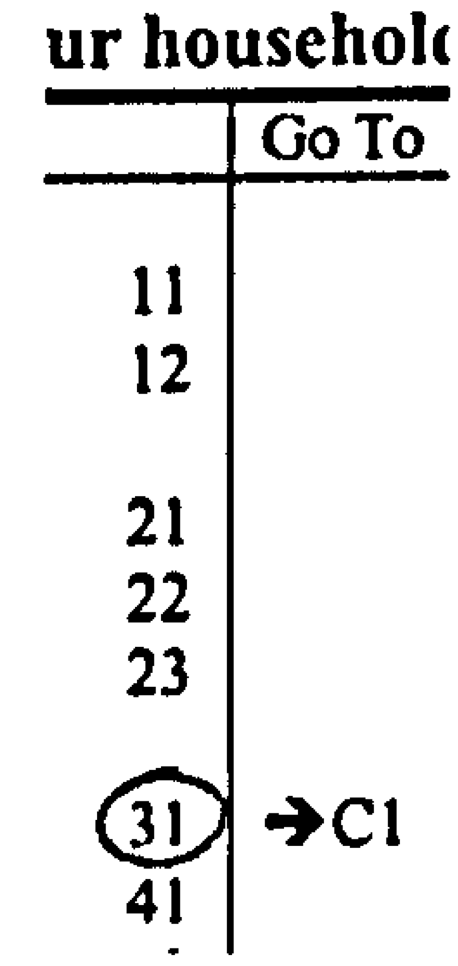
Only if the water is on for most of the day is it considered improved. Intermittent sources will be discussed below. In this survey public stand-posts will be considered in this category when the y supply piped water at the public tap-stand. There is an assumption that if the water source is not intermittent the quality will be improved. This might need checking in some cases.

Tanker truck, vendor

In this case the vendor is considered a mobile vendor and not a static vendor. Households buying water from a fixed vendor are considered under the above categories, according to the type of source de vendor uses. In this survey, a vendor is anybody delivering water to the household.

Bottled water

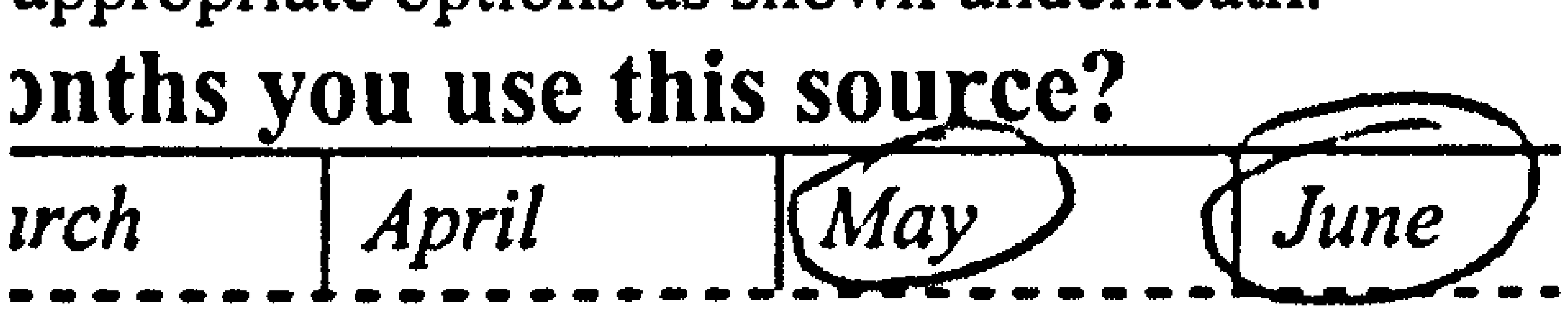
Water sold in bottles and filled in an industrial facility.

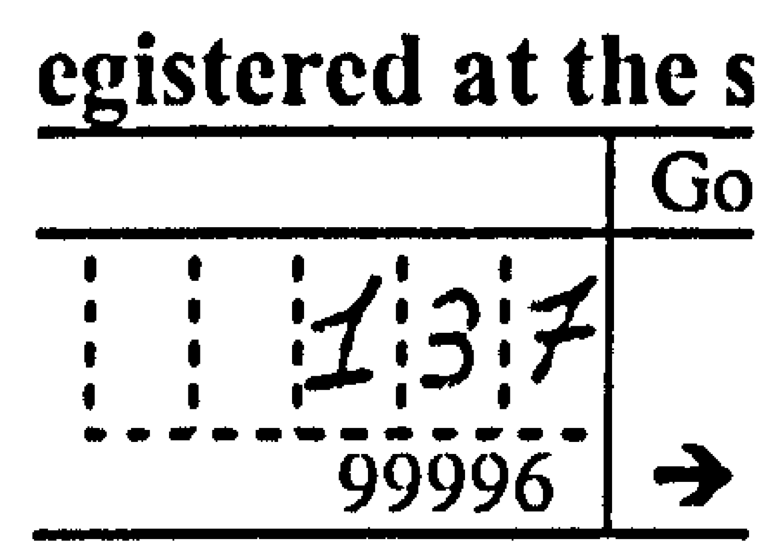

ur househol(
Go To
11
12
21
22
23
31 →C1
41

G.6 How to mark the answers?

To answer the question just draw a circle around the number behind the answer. In case there is a question reference behind the answer in the 'go to' column as shown in the figure on the right, proceed to that particular questions. In case a number is requested fill it clearly into the boxes provided as shown in the picture below.

If and only if more options are allowed circle the appropriate options as shown underneath.


onths you use this source?
rch | April | May | June


egistered at the s
Go
1 3 7
99996 →

If the answer is NOT in the list provided AND an option is to specify 'other' please do so in CAPITAL letters as shown. Do not forget to draw a circle around the number of the answer you provided which is right of the space provided to write the answer. (see picture)


OTHER_RAINWATER________ 96
(Specify)

When you are doing your coding the information you give is as useful as it is readable and to prevent you from having to go back to check it again, please write readable.

H Bibliography

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Task specifications for a Computer household Sampling Simulation

Introduction

Standard sampling is based on a random or known probability for each of the basic sampling units (BSU) included in the sample. This is generally done by making a list of BSUs (e.g. households) from which a selection is made. In low income countries, lists of households are not always available or up-to-date. Creating these lists known as 'sample frames' requires considerable efforts and costs and is not always possible (e.g. exclusions by local authorities of some population groups from the list). To address this problem WHO adopted a method that allowed for accurate data collection in its 'expanded programme of immunisation' (EPI). These methods have been accepted and their reliability was later confirmed by computer simulations. Some suggestions for improvement have also been proposed and demonstrated through computer simulations. EPI-sampling, as this method is generally referred to, has allowed WHO and UNICEF to measure the efficiency of the immunisation programs they support. Unfortunately the popularity of EPI-sampling has made that this approach has been inappropriate used by lack of other accepted methods or understanding of its limitations. This resulted in collecting non representative data on which decisions and conclusions were made.

Other suggestions have been made in the literature to improve and adapt the EPI methodology, but most of them undermine its simplicity, while it is difficult to assess whether these add significantly to the accuracy or validity of the measurement. (Additional requirements for the water sector. Estimates of roh.)

Goal of designing a simulator

The goal of the simulator is to apply three sampling methodologies repeatedly in a GIS environment to allow the study of their performance through exhaustive resampling. The aim is to sample each situation 10'000 times. Two methodologies are without a sampling frame and one represents random sampling as a control. (The different methodologies are explained below.) This will allow sampling in a controlled environment and will also determine the conditions under which each sampling method performs best. The advantage of using a simulation is that the various sampling methods can be compared with a simple random sample as well as with the population figures.

Using a GIS environment allows using real data as well as simulated data. While for the moment the concentration is on rural areas, in the future to extending this tool for developing alternative sampling methods for urban, mainly slum areas might be considered.

The type of experiments we would run is generally referred to in statistics as Monte Carlo simulations although more complex approach such as bootstrapping could be considered.

Research needs

The biggest problem to achieve such a simulator seems to be the programming of the simulations in the GIS environment and linking the data output with a statistical software package. We are looking for professional programmers, preferable in industry to help us building a sampling simulator.

We estimate the work would take for an experienced programmer 5 full working days and some hours a month to finalise the simulator during the testing over the period of ½ to 1 year.

Alternatively the project could fit a MSc summer project in geomatic engineering but we fear that there might be a problem of continuity in the long run once the student finishes his/her degree unless supervisors would be able to guarantee that continuity.

Development tools

We would prefer the system being develop in software that can run under Linux or Windows and the GIS packages suggested are:

- GRASS 5 (C++ under LINUX or Windows) UK mirror side http://www.fieldinstruments.co.uk/grass/)
- IDRISI 32 (C++ under WIN or Linux)
- ArcGIS 8 (C++ or V.Basic under Windows)
- ERDAS 8

These software environments are, or can be available to the London School of Hygiene and Tropical Medicine. Other tools might be considered in discussion with the LSHTM.

Geo-statistical analyses of the simulators results will be done with the software that is part of the GIS software. For other statistical analyses Stata ver. 8[1] or higher is used although SPSS ver. 11[1] or higher can be considered.

Statransfer ver. 7[1] is suggested for transforming data set from one format to another.

Sampling methods

Simple random sampling

The gold standard in sampling is the simple random sample in which any household in the population has an equal (non zero) change of being selected.

EPI derived sampling method

The sampling used for this purposes is a multistage cross-section population sample. The first stage will always be based on mutually exclusive and exhaustive primary sampling units (PSU's). PSU are generally rural villages or urban neighbourhoods which are selected by probability proportionate to estimated size (PPES). The second stage will be various sampling methods like the one used by the WHO's Expanded Programme of Immunisation and potential adaptations suggested in literature (information pack already prepared and available).

E.g. after (PPES) selection of the PSU's the EPI method starts at the estimated middle of the cluster and selects all the houses in one straight line of a random direction. From the selected houses one is randomly selected and used to make the first measurements if a child is found. From here on the field-officer moves to the next house that is the closest to the former one until enough samples are found.

This method is simple and often used in vaccination programs. It is however suspected that households in dense areas have more change to be selected than households less dense areas.

[1] Or a more recent or updated version can be used.

Variations as suggested by the late Professor of Medical statistics, Steve Bennett (former statistician on this project) will be integrated in this method as well as other suggestions for 'improvements' available in literature (literature pack available).

Random geo-location method

A random geographical local is chosen and the nearest household to that point is selected. This method is expected to result in an opposite bias compared to the EPI method because households in areas of lower population density have more chance of being selected.

Analyses

Analyses will be on the bases of the times the household is been selected in 10'000 iteration of the sampling protocol as outcome. The explaining factors in the analyses will be the household density as shown in Figure 1, distance from the centre as shown in Figure 2, and distance from the water source in Figure 3 by multiple regression analyses.

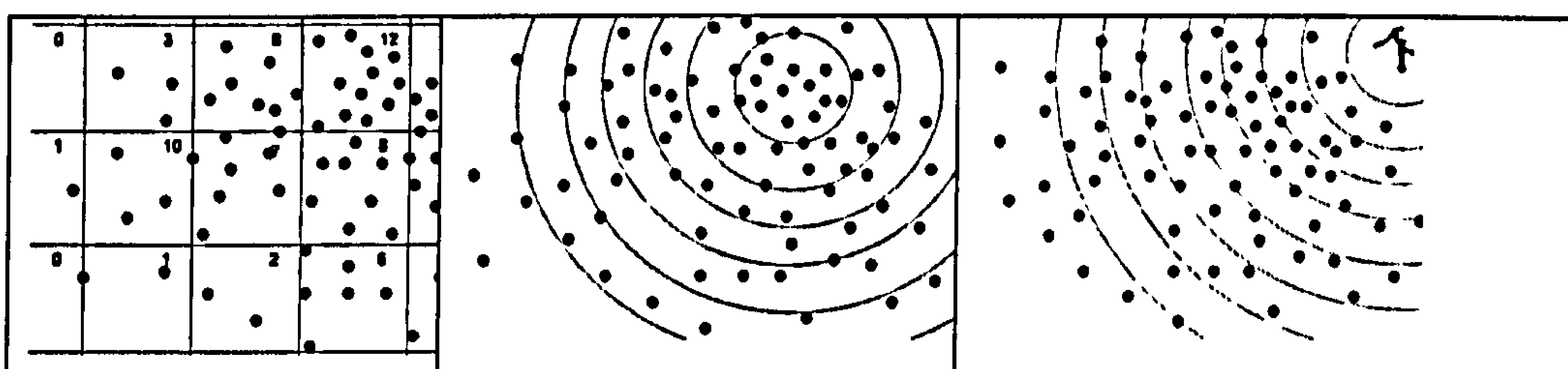

Figure 1: House density | Figure 2: Distance from centre | Figure 3: Distance from water source

Figure 1: House density

Figure 2: Distance from centre

(Sampling starting point / centre of most dense area (square) in figure 1

Figure 3: Distance from water source

Planning of the work

Part one:

- Test random generator on computer and in program and write corrections if necessary.

  Random generators in computers have been notorious for not being that random at all. This is well documented and some methods have been suggested to address this problem.

- Generate a random geographical point in an area delimited by an outer boundary (or by an existing polygon (preferred) or by a rectangle in which Δx and Δy are defined as a rectangle).
- Validate the algorithm. E.g. One of the ways in doing this is to create a file with all these random generated points in one file and create a density raster of which the variance in the raster will tested to see how random the algorithm is.
- Generation of simulated clustered households and simulated access to water data if not available.

Part two:

- Design a program for the three simulated sampling protocols
- Simple random sampling (and test its validity)
- EPI derived method
- Random Geo-location
- that allows sampling from existing data set.
- Allow density on different data to be added to the dataset. (Automatic or document the protocol to do this)
- Design an option for the visualisation and calculation of the data process e.g. the distance a survey team has to walk.

Part three

- Automate analyses of data sets in STATA or SPSS which could dramatically speed up analyses.
- Analyses determining which factors in the population and in the sampling method are critical in taking sample that represents the population.

Status of the project

All the preparative work has been finished an can be made available to any person interested to support us in our quest.

Support for a person willing to get involved.

General guidelines on the project and extensive discussion prior to the project will be possible with Kristof BOSTOEN the project leader. Guidelines on how the statistical

WATER AND SANITATION MODULE (UNICEF 1999)		
1. WHAT IS THE MAIN SOURCE OF DRINKING WATER FOR MEMBERS OF YOUR HOUSEHOLD?	Piped into dwelling .... 01 Piped into yard or plot .... 02 Public tap .... 03 Tubewell/borehole with pump .... 04 Protected dug well .... 05 Protected spring .... 06 Rainwater collection .... 07 Bottled water .... 08 Unprotected dug well .... 09 Unprotected spring .... 10 Pond, river or stream .... 11 Tanker-truck, vendor .... 12 Other (*specify*) ______________ 13 No answer or DK 99	

Figure 12: Example of question from MICS survey.

This question combines roughly five different types of information which are not always well-defined, and some combinations of these five different types of information are not available as answers.

Question S11 contained the following types of information:

1. Type of source:
   Well, river, stream, spring, bottled...
2. Location:
   Dwelling, yard, plot, ...
3. Type of access:
   Public, private, ...
4. Protection:
   Protected, unprotected
5. Type of delivery:
   Piped, tanker truck, house to house vendor

To explain clearly the criteria involved in each aspect of the question is not a problem, but when combined in a single question it proved to be difficult and confusing for the fieldworkers to apply these issues. One solution for the future could be to split up the question into smaller questions. These would be easier to define as each would involve only one concept. These questions should not take much longer to pose in a survey, as more than 50% of the time in the survey (excluding travel time to each village) is spent in going from house to house. It would also give clearer information on the water source, its characteristics and the constraints to access. Splitting up the questions would allow easier and more accurate translation, and help to clarify the practical definitions used in the survey. Some of the questions would then need an option for 'I do not know' where this is a plausible answer; for example, the original source of the water collected from a tap.

During the survey we found that some surveyors considered the possibility of leaves falling into the well (even if there were no trees around the well) was a clear justification to treat it as 'unprotected', although they did not always check for the protection from runoff as specified in their training. Leaves might be a perceived validity will be done can be obtained from Kristof BOSTOEN, while the testing itself will be done by Kristof.

Specific statistical support, if required can be obtained from Dr Steve Bennett.

Kristof and Steve work both at London School of Hygiene and Tropical Medicine which is close to British Museum. Most of this support will be by E-mail and by phone, apart from the discussion prior to the project. However face to face contact will be preferred particular at the start of the project.

Preliminary literature on the topic is available on request.

Existing geo-referenced data will be made available when needed.

Time scale.

Although we would like to start as soon as possible, most of the intensive testing of the simulator can only start at the beginning of June 2002 due to existing work load. We hope to run the bulk of the simulation at the latest by the end of August 2002 and hope this initial testing will take no longer than a month.

Enumeration

There is scope for academic and non-academic publications which is something to be discussed at the beginning of the project. Travel cost can be reimbursed on prior agreement, but as nobody is paid for this project there are no financial benefits for people involve in the project at this stage.

For any queries do not hesitate to contact Kristof.bostoen@lshtm.ac.uk tel. work 02079272439 or mobile 07880 611 227

Kind regards

Kristof

Selection of Primary Sampling Units (PSU's)

Ref. PSU	Nr. of BSU's in each PSU	Cumulative Number	Selected PSU	(k) + 2436=
1	753	↓ 753		
2	564	+ 753=1317	1199	3635
3	251	1568		
4	654	↓ 2222		
5	562	+2222=2784	<	
6	954	3738	≥ 3635	6071
7	1564	5302		
8	654	5956		
9	987	6943	6071	8507
10	369	7312		
11	236	7548		
12	784	8332		
13	852	9184	8507	10943
14	954	10138		
15	1596	11734	10943	13379
16	845	12579		
17	738	13317		
18	760	14077	13379	15815
19	571	14648		
20	258	14906		
21	661	15567		
22	569	16136	15815	18251
23	961	17097		
24	1571	18668	18251	20687
25	661	19329		
26	994	20323		
27	376	20699	20687	23123
28	243	20942		
29	791	21733		
30	859	22592		
31	961	23553	23123	25559
32	1603	25156		
33	852	26008	25559	27995
34	745	26753		
35	767	27520		
36	578	28098	27995	30431
37	265	28363		
38	668	29031		
39	576	29607		
40	968	30575	30431	32867
41	202	30777		
42	750	31527		
43	818	32345		
44	920	33265	32867	35303
45	1562	34827		
46	811	35638	35303	37739
47	704	36342		
48	726	37068		
49	537	37605		
50	224	37829	37739	40175

The table on the left is a typical table that has to be created to select the clusters from the available PSU's.
The first column is the reference of each PSU which normally is a name but can also be a number as in our example. These PSU's should not be ordered in any way in the table.
The second column contains the number of BSU's (households in our case) for each of the PSU's.
The third column is the cumulative number of households in the PSU's in the order as they appear in the listing. In our example they are obtained by adding the number of BSU's of all the PSU's mentioned above.
For example the cumulative BSU's for PSU with reference nr. 7 is **5302** households. This obtained by adding up the number of PSU's from 1-6 or

Ref. PSU	Nr. of BSU's in each PSU
1	753
2	564
3	251
4	654
5	562
6	954
7	1564
TOTAL	5302

A faster way of calculating this is by taking the cumulative value of the PSU before which is in cell above and add the value of the new PSU. For PSU 7 this would mean to take the cumulative value of PSU 6 (=3738) and add the number of BSU's (1564 households) which give the same value (5302 households) for the cumulative value of PSU 7. Two other examples (PSU 2 &5) are shown in the table.
The sampling we would perform would be 32 cluster (c) of 33 samples (b). These 32 cluster will be selected in our example from the 105 PSU's in the table. The method used for this selection is a 'systematic probability proportionate to sample size'.
To do this we have to know how many BSU's (households) (N) are in our population. In our example this value is 77'953 households.

$$k = \frac{N}{b} = \frac{77953}{32} = 2436$$

So by selecting the PSU in which each

Ref. PSU	Nr. of BSU's in each PSU	Cumulative Number	Selected PSU	(k) + 2436=
51	627	38456		
52	535	38991		
53	927	39918		
54	1537	41455	40175	42611
55	627	42082		
56	960	43042	42611	45047
57	342	43384		
58	209	43593		
59	757	44350		
60	825	45175	45047	47483
61	927	46102		
62	1569	47671	47483	49919
63	818	48489		
64	711	49200		
65	733	49933	49919	52355
66	544	50477		
67	231	50708		
68	634	51342		
69	542	51884		
70	934	52818	52355	54791
71	168	52986		
72	716	53702		
73	784	54486		
74	886	55372	54791	57227
75	1528	56900		
76	777	57677	57227	59663
77	670	58347		
78	692	59039		
79	503	59542		
80	190	59732	59663	62099
81	593	60325		
82	501	60826		
83	893	61719		
84	1503	63222	62099	64535
85	593	63815		
86	926	64741	64535	66971
87	308	65049		
88	175	65224		
89	723	65947		
90	791	66738		
91	893	67631	66971	69407
92	1535	69166		
93	784	69950	69407	71843
94	677	70627		
95	699	71326		
96	510	71836		
97	197	72033	71843	74279
98	600	72633		
99	508	73141		
100	900	74041		
101	134	74175		
102	682	74857	74279	76715

k^{th} BSU (household) is found we will end up selecting 32 PSU's. To avoid starting always with the first PSU in the list (which could lead to bias) we have to select a random value between 1 and k (=2436 in our example) both values included. This can be done using random tables as those attached to this document. Using the tables we obtained 1199 as starting value. The 1199^{th} BSU can be found in PSU 2 as the 753^{th} BSU is the last one of PSU 1 and the last BSU of PSU 2 is the 1317^{th}. The 1199^{th} is between these two values. The next PSU can be found by adding k to 1199 which

$$\begin{array}{r} 1199 \\ +2436 \\ \hline =3635 \end{array}$$

equal to 3635 as shown in the last column. The 3635^{th} BSU can be found in PSU 6 as this value is larger than 2784 and equal or smaller than 3738.

Continuing like this in the table 32 PSU's will be selected.

Some exceptional situations

If it is not possible to keep number of BSU in each of the PSU's low it might occur that the PSU is selected twice. The selection of 33 samples as done in each selected PSU (or cluster) will have to be done twice making sure that no BSU is sampled twice.

Ref. PSU	Nr. of BSU's in each PSU	Cumulative Number	Selected PSU	(k) + 2436=
103	750	75607		
104	852	76459		
105	1494	77953	76715	
TOTAL	77953	Nr of PSU's	32	

F Calculating estimated number of surveyors required in the *WaSH* survey based on expected work load.

Estimated number of surveyors required for data collection.

The estimated interview contact time for the *WaSH* survey is 20 to 30 minutes with 15 minutes required to find the next household. So around ½ to ¾ **hour** are needed **per interview.**

This would mean that surveyors be able to average 10 interviews/day.

32 x 32 samples **1024 samples**

12 surveyors x 10 surveys/day x 10 days = 1020 (excluding WE work)

12 surveyors x 10 surveys/day x 14 days = 1680 (including WE work)

(1680-1024)/1024 is 64% over capacity in interview resources to do revisit and visit extra households to compensate partially for non-response.

Some surveyors will have to work in the WE to capture the households which were not available during the weekdays.

Estimated number of observers required for data collection.

The number of observers was more pragmatic. With 10 observers and 10 days of observation it was possible to have a sub sample of more than 95 households which would gives estimates within 10% CI for the worst case of 50% prevalence.

This will allow validation at the population level only when the prevalence is either very high or very low.

Draft training schedule for Kenya survey training programme

VISION 21 MONITORING INDICATORS

Training Program for Enumerators 19th - 20th Feb 2003

08 30 – 10 30	To get to know one another through paired introductions in groups	BK/KB
	To introduce Netwas and LSHTM	VN/KB
	Brief about the study, and general overview of the study, Basic data on Low Income Peri urban areas.	KB/BK
	Role/work of an enumerator. Expected output, Accurate representation, legible clear input sheets, 10 Hrs per day time line.	KB/VN
	Role of supervisor LSHTM, Netwas, Daily reviews, Support, certification	KB/BK
	Logistics, Agreement, transport, fees.	BK/KB
10.30-10 45	Tea Break	
10.45 – 1 00	Introduction to Data collection Tools ; The questionnaire	KB
	Methods for asking questions, do's and dont's ,climate setting, closing the interview, filling in the Questionnaire	BK
	Methods for accurate data collection, do's & don't, Recordings	VN
	Role play, Why, communicating, body language Safety first, dealing with aggression and insecurity	VN
1 00 – 2 00	Lunch	
2 00 – 5 00	Translate questionnaire in Swahili	VN/BK
	Practice asking questions in Swahili	
8 00 – 9 00pm	Role play questionnaire in Swahili	BK/VN
	Day Two Thursday 20th Feb 2003	
8 00 – 12 00	Pre-test Questionnaire in field (Soweto), in groups of three interview house holders, critic each other and then try once more.	BK/KB/VN/ GM
1 00 – 2 00	Lunch	
2 00 – 3 00	Review Questionnaire and fine tune using field experience	VN/BK/KB
3 00 - 3 45	Sampling, coding	KB
3 45 – 4 00	Tea, coffee	
4 00 – 5 00	Are We Ready for field?. Logistics, Transport, Meeting place, Concern offices, Security & Elders, Daily Reviews, Daily Experience Recordings, Certification, Fees, Fares, Agreement	BK/KB/VN

VISION 21 MONITORING INDICATORS

Training Program for Observers 21st - 22nd Feb 2003

	Day One Friday 21st February 2003	
08.30 – 10.30	To get to know one another through paired introductions in groups	BK/KB
	To introduce Netwas and LSHTM	VN/KB
	Brief about the study, and general overview of the study, Basic data on Low Income Peri urban areas.	KB/BK
	Why the study, Vision 21 Indicators,	
	Role/work of an enumerator. Expected output, Accurate representation, legible clear input sheets,	KB/VN
	Role of supervisor LSHTM, Netwas, Daily reviews, Support, certification	KB/BK
	Logistics, Agreement, transport, fees	BK/KB
10 30-10 45	Tea Break	
10 45 – 1 00	Introduction to Data collection Tools , The questionnaire	KB
	Methods for Accurate Observations, do's & Don't, Recordings	VN/BK
1 00 – 2 00	Lunch	
2 00 – 5 00	Methods for Accurate Observations, do's & Don't, Recordings continues	VN/BK
8 00 – 9 00pm	Role play questionnaire in Swahili	BK/VN
	Day Two Saturday 22nd Feb 2003	
8 00 – 10 30	Research Methods,Sampling, coding, The Gold Standard	KB/VN
10:30 – 1.00	Review tool, past experiences	KB/VN
1 00 – 2 00	Lunch	VN/BK/KB
3 00 - 4 00	Are We Ready for field?. Logistics, Transport, Meeting place, Concern offices, Security & Elders, Daily Reviews, Daily Experience Recordings, Certification, Fees, Fares, Agreement	KB/BK/VN

BK: Beth
VN. Vincent
GM Gilbert
KB Kristof

Annex H Overview of survey areas in Nairobi

This annex contains the information on the informal settlements Kware, Soweto and Korogocho suggested by NETWAS as possible alternative locations for field testing the *WaSH* survey methodology. Original the survey was planned in Mathare informal settlement which is around 10 km north from the city centre but due to civil unrest over the partial demolition of some parts and discussion of ownership of dwellings in the slum the, security levels dropped. NETWAS considered it unwise to do such activities at the time. Information was collected on alternative locations on a familiarisation tour of the area held on the 21st January 2003.

KWARE VILLAGE – ONGATA RONGAI

Administratively

The village is located about 20 km south-south-west from Nairobi City centre. Administratively, the village is in Ngong Division, Kajiado District, Nkai Murunya. The local authorities are:

- Chief: Ole Tawuo mobile number 0722 831355
- Assistant Chief: Gitau mobile number 0722 731371
- Chief's Secretary: Francis Mutungi

They are very willing and ready to assist us with our field trial in their communities There are lists of households due to the reorganising with the plot resizing.

Population

According to the census of 1997, the settlement had a population of over 22,000 people of which were considered 18,000 squatters. Most of these are born and brought up here in the settlement. After a recent reorganisation of the formal and informal part of the settlements the area was divided into plots of 40 X 80ft (12X24m) which usually are jointly owned by 3 to 4 households living on the plot. The slum has according to the local authorities about 3000 households with on average 5 members. However there is some discrepancy as:

3000 (households) X 5 (members/household) = 15 000 people $\neq$ 22 000 people said to be living in the settlement. An average of 22 000/3 000=7 pers/household seems according to the local not impossible. The majority of active population in the settlement work as casual labourers.

Village Set-up

The location is made up of 3 sub locations, namely: Embakasi, Olkeri and Kandisi Due to the large population, the area is run through the assistance of village elders chosen to represent various sections of the settlement.

Water and Sanitation Facilities

The slum has no permanent water source. The piped water system, laid down by the government through a nearby self help project, broke down and has not been repaired. The population rely on water peddlers who sell water in jerry cans at sh10 per 20l. Most of the plots have semi permanent toilets but obviously are not enough for the large population. The village looked relatively clean and they have solid waste disposal pits strategically placed in the village. They still have a problem with the plastic paper bags which they try to burn.

Primary Schools

There are two main public Primary schools namely:

- Ongata Rongai Primary School – about 1100 pupils
- Nakeel Primary School - about 800 pupils

There are also a few private schools and one Secondary School in the area. There is also a rehabilitation centre set up by the church to rehabilitate boys and girls.

Public Health Services

The office of the chief together with the Public Health Technicians occasionally hold seminars and training sessions on family planning; water and sanitation related diseases e.g. typhoid and malaria which are very common; HIV/AIDS among others. There are about 10 Public Health Technicians in the village who carry out day to day observance of public health issues.

SOWETO VILLAGE – KASARANI DIVISION

Administratively

This village is relatively small and is located in Kasarani Division of Nairobi City about 25kms from the city centre. The village is in Kahawa Location and headed by Chief Joseph Kalio. The village elders run the day to day administrative affairs of the village assisted by the local chief and assistant chief.

Population

According to the 1997 census, the village had a population of about 5000 living in 708 households. The above figures would mean around 7 people per household. Most of the village dwellers were born and brought up in the village and have lived there for over 20 years.

Water and Sanitation Facilities

The village is served by the water from the city council and is sold in jerry cans to them at sh.3 per 20l. They have mainly communal toilets due to the small sizes of their plots. Only about on quarter of the population own or have access to the pit latrines. The rest use open defecation including 'flying toilets'. The youth in the village do garbage collection and burn the garbage just outside the village.

Primary Schools

The village has two public primary schools namely: Mahiga primary school (although bit far from the village) with over 950 pupils and Kahawa primary school with over 1131 pupils. There are also private schools in the location.

Other Services

The village does not enjoy the services of public health technicians but it receives support from NGOs such as World Vision. These NGOs carry out public health seminars and training.

Contact Persons in the Village

Ms. Anastasia Wairimu (Wa Leah) – Village elder –telephone number 02 810401

KOROGOCHO VILLAGE – KASARANI DIVISION

According to inhabitants the name Korogocho is derived from one of its first inhabitants Kanau Wa Kiane arriving in 1962. Every time she was asked for anything she would answer 'Korogocho' which in Kikuju means matchbox without matches. She might have had a vision on things to come as matchboxes would be a good description of the houses that cover the whole of Kororgocho.

When the first inhabitants started streaming into Korogocho it has into a place now referred to Gitathuru Central. Later people working into a nearby quarry settled into Korogocho 'A' and Nairobi city council resettled people in Korogocho 'B'. Despite local MP's facilitated the expanding of Korogocho in areas like Highridge nobody in Korogocho has ownership of the plot it is living. Families were resettled by the government from Nairobi city centre on the promise of ownership of plots of land. When that did not materialise they moved to Grogan 'A' and 'B'. While the land is still owned by the government the superstructures are owned by the first settlers but with lucrative rents a lot of the owners are from outside Korogocho informal settlement.

Administratively

Korogocho village is a large settlement located in Kasarani Division. It is headed by Chief Mutai and has several sub-locations and assistant chiefs. The settlement is made up of eight villages:

- Kisumu Ndogo (divided in Main & Nyayo)
- Korogocho A
- Korogocho B
- Highridge
- Gitathuru
- Ngunyumy
- Grogan A
- Grogan B

Although the chief and his Assistant chief were willing to host us, they advised us that for security reasons, we would have to get clearance from the Nairobi Provincial Commissioner's Office. This would then enable his office to assign us proper and adequate security throughout the study period. The elder considered Grogan A and B too dangerous to be included in the study. According to the elder the lawlessness of that part of the settlement made them very reluctant to assist us there.

Population.

According to the 1997 census, Korogocho had a population of about 150,000

Water and Sanitation Facilities

There is a drainage system that was left uncompleted by the implementing agency that is according to the local authorities a causes many health problems especially during the rainy season due to storm water. Water supply is from the Nairobi City Council through water selling kiosks strategically placed in different parts of the village. The water is sold from these kiosks at 2 to 3 shillings per 20lt and collected in jerry cans or other recipients. The amount of water is considered insufficient in quantity and often contaminated due to leakages in the pipe system. There are pit latrines in various parts of the village many made up of ordinary latrines while some latrines are ventilated and considered to be VIP latrines. It is estimated that only one quarter of the population have access to latrines and open defecation and flying latrines is commonplace. Water and sanitation related diseases like malaria, typhoid, cholera (sometimes), TB and HIV/AIDS are common (sic).

Primary Schools

There are two main public primary schools in the village, namely: Kiboni Primary School with about 2000 pupils and Ngu Nyumu Primary School with about 1,500 pupils

Public Health Services

Although the settlement has such a large population, there are no community health workers active. Public health related issues are mainly carried out by the numerous NGOs such as *'Provide International'* as well as Church and church related agencies

Contact Persons

Chief's Office – Chief Mutai - mobile telephone number – 0722 604671

PAGE NUMBERING AS ORIGINAL

WATER, SANITATION AND HYGIENE SURVEY; A TRIAL IN THAKHEK DISTRICT, LAO PEOPLE'S DEMOCRATIC REPUBLIC
SEPTEMBER 2003

Final report to

The Energy and Water Department,

The World Bank

by

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Lao Ministry of Communication, Transport, Posts and Construction

February 2004

WSSCC | World Bank | WSP-EAP | URI | LSHTM

Executive Summary

By any standards, the people of the Lao PDR have limited access to improved water supply and basic sanitation, as a result of financial, social, technical and cultural constraints. The Lao Government is committed to reaching the MDG targets of halving the proportion unserved with water and sanitation. However it is clear that for the moment, sanitation is falling behind in the efforts to meet these targets.

The trial of the WASH[1] survey for water, sanitation, and hygiene practices in Thakhek District, Lao PDR, is part of an initiative coordinated by the Water Supply and Sanitation Collaborative Council to develop new indicators and improve data collection for the water and sanitation sector. Besides the traditional questionnaires, other methods were used for data collection, including spot observations and pocket voting.

The survey found that 58% ±7% of households do not have access to an 'improved' water source, more than twice the 26% stated by the Statistical Office in Thakhek District. The survey also found that 59% ±9% of households do not have access to 'improved' sanitation while the local Statistical Office figure is 48%.

The survey confirmed:

- The WASH survey can be designed so that in its minimal form, the average contact time for each household is no more than 10 minutes.
- The best time for data collection is during the early morning and late evening, when people are at home. In a subsistence economy, these times are better than the weekend.
- It is often possible, as in Laos, to build a sampling frame using existing registration systems or survey data.
- The concept and rules of representative sampling are difficult to comprehend and considered cumbersome to adhere to by implementing organizations.
- Design effects for access to water and sanitation are high which means that in some circumstances when it might be cheaper to do random sampling instead of cluster surveys.

[1] We refer to the survey method as used here the WASH survey method, as it has been developed under the auspices of the the WSSCC WASH campaign.

Acknowledgements

We thank the Water Supply and Sanitation Collaborative Council (WSSCC) for their support in developing a water and sanitation sector-specific survey methodology for monitoring access to water and sanitation, and the Energy and Water Department of the World Bank for its financial support of the WASH survey trial in Lao PDR and the development of the WASH survey methodology.

Our greatest thanks go to the Thakhek Provincial Authorities, the Administration Office, and the local Department of Communications, Transport, Posts and Construction, for their extensive support and cooperation in making this survey trial successful. Our acknowledgement also goes to The World Bank's Water Supply and Sanitation Program-East Asia Pacific, the Heads of the 32 villages involved, and all villagers for their support and cooperation with the study team during the survey. Finally, we would like to express our appreciation for the cooperation of everybody involved in the trial, even if not explicitly mentioned, without which it would not have been so successful.

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Abbreviations and Acronyms

BSU	Basic Sampling Unit
CDC	The Centers for Disease Control and Prevention, Atlanta
DCTPC	Department of Communication Transport Post and Construction
DHS	Demographic Health Survey by MACRO for USAID
GA2000	Global Water and Sanitation Assessment 2000 report by JMP
GHS	Global Health Survey by WHO
GPS	Global Positioning System equipment, to plot locations on maps
IAP	Iguaçu Action Plan
IT	Information Technology
JMP	Join Monitoring Program by UNICEF and WHO
LSHTM	London School of Hygiene and Tropical Medicine
LSMS	Living Standard Measurement Survey
MCTPC	Ministry of Communication Transport Post and Construction
MDG	Millennium Development Goal
MICS	Multiple Indicator Cluster Survey by UNICEF
Nam Saat	National Centre for Environmental Health and Water Supply
NIPH	National Institute of Public Health
MoH	Ministry of Health
PDA	Personal Digital Assistant (Pocket or Palm Computers)
PSU	Primary Sample Unit
UDAA	Urban Development Administration Authority
UNICEF	United Nations International Children Emergency Fund
URI	Urban Research Institute
USAID	United States Agency for International Development
WASH	Water, Sanitation and Hygiene Campaign of WSSCC
WHO	World Health Organization
WSP-EAP	Water and Sanitation Program – East Asia and Pacific, the World Bank
WSSCC	Water Supply and Sanitation Collaborative Council

Part 1 : Introduction

1. 1. Background

The Lao Government regards water supply and sanitation as very important to improve people's living conditions. It has therefore strengthened its water and sanitation service sectors, assigning roles to several agencies such as the Ministry of Public Health and the Ministry of Communications, Transport, Posts and Construction.

Despite being quite different in nature, water supply and sanitation are often mentioned together. In practice, water supply tends to receive more resources, and water coverage targets are closer to being achieved than sanitation targets. The strategy for the Lao water sector has been defined by the Water Supply Authority, which takes responsibility for water improvement in urban areas. The Ministry of Health is responsible for rural water supply. However, the strategy for sanitation is still unclear.

The ability to measure access to water and sanitation will determine the country's ability to define needs and state achievements accurately.

This document reports on a water, sanitation and hygiene (WASH[2]) survey trial in Thakhek District, Lao People's Democratic Republic (Lao PDR). It is a contribution towards the Iguaçu Action Plan (IAP) objective to improve data collection for the water, sanitation and hygiene sector globally, and to develop new indicators and methods where necessary. The survey was a collaborative effort between the Urban Research Institute (URI) of the Lao Ministry of Communications Transport Post and Construction (MCTPC), the World Bank's Water and Sanitation Program – East Asia and Pacific (WSP-EAP), the Water Supply and Sanitation Collaborative Council (WSSCC) and the London School of Hygiene and Tropical Medicine (LSHTM). It was supported financially by the Energy and Water Department of the World Bank.

The WASH survey method aims to improve data collection specific for the water, sanitation and hygiene sectors by creating a base for a sector-specific survey tool. It is part of an effort to achieve the Vision 21 targets and the Millennium Development Goals (MDGs). In this global context, the trial in Laos had two specific goals: to look at the indicators in an Asian setting, and to measure the design effects of the indicators in a full survey.

1. 2. Vision 21 and Millennium development goals

Water supply and sanitation coverage target are included in the Millennium Development Goals. The target to reduce by half the proportion of the world's population lacking access to water supply by 2015, was set at the Millennium Summit. A similar target for sanitation was added at the Johannesburg Summit in 2002. Additional targets including hygiene and school sanitation were set in Vision 21 (Table 1). The baseline to measure progress towards the MDGs is the position in 1990 as stated in the Global Water Supply and Sanitation Assessment Year 2000 Report

[2] We refer to the survey method as used here the WASH survey method, as it has been developed under the auspices of the WSSCC WASH campaign.

(WHO/UNICEF 2000). This report was compiled by the Joint Monitoring Program (JMP), a joint collaboration between WHO and UNICEF, with the task measuring the worldwide progress of water and sanitation towards the MDG targets.

	Vision 21 suggested targets for <u>2015</u>	**For <u>2025</u>**
1	Universal public awareness	Good hygiene practices universally applied
2	Percentage of people who lack adequate sanitation halved	Adequate sanitation for everyone
3	Percentages of people who lack of safe water halved	Safe water for everyone
4	80% of the children educated about hygiene	All primary school children educated about hygiene
5	All schools equipped with facilities for sanitation and hand-washing	
6	Diarrhoeal disease incidence reduced by 50%.	Diarrhoeal disease incidence reduced by 80%

Table 1: The Vision 21 targets, with MDG targets for the sector in shaded boxes.

The Year 2000 Report was the first global assessment using population-based water supply and sanitation coverage data, but it still has some limitations. The first limitation is that the data are derived from surveys such as DHS, MICS and LSMS which have been **carried out for other sectors,** in which water and sanitation questions have been added to the questionnaire. These surveys thus contain **little information on hygiene practices**. Another limitation is that **different standards** and sometimes even wrong definitions for "access" are used in some countries. The data is based on national surveys, which result in **data at national level only,** with little possibility of disaggregating. The size and costs of such efforts result in **inappropriate frequencies and timing** of surveys, from the point of view of MDG monitoring in the sector.

The development of a sector-specific WASH survey protocol aims to overcome these limitations, and improve data collection for monitoring progress towards the MDGs in the water, sanitation and hygiene sector.

1. 3. Survey Methodology

This part gives a brief overview of the survey methodology. In practice it can be considered under three very different heads, as illustrated below.

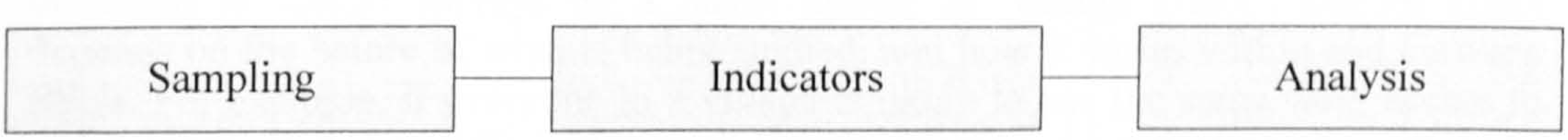


Figure 1: Survey Methodology

1. 3. 1. Sampling

Most statistically untrained people are unaware of the difficulties and pitfalls of sampling. The biggest problem is not the application of statistical formulas but the selection of households from which the data is collected. All formulas used in statistical analyses are only relevant if the data collected is representative for the population. This is often not the case because the surveyors are unaware of the requirements of representative sampling. Once the data have been collected, it is not possible to determine how representative they are, from the data alone. Sampling rules must therefore be rigorously applied to make the data as representative as possible, and data sets also need to be well documented in that regard.

After obtaining a representative sample, results are obtained by applying statistical formulas. Freely available statistical software (CSPro http://www.measuredhs.com/cspro/start.cfm and Epi-info http://www.cdc.gov/epiinfo/) can facilitate calculations and tabulation of survey results. These are recommended for analysis of WASH survey results.

BSUs and PSUs

Access to water and sanitation services is commonly defined for practical purposes at the household level; surveys are used to estimate the fraction of households which have access. Thus households are the Basic Sampling Unit (BSU) for the survey. However, randomized surveys of households are difficult to achieve in low-density rural areas, where there is frequently no easy way to identify the total population of households, or to manage the logistics of visiting a completely random sample of households, no two of which are likely to be in the same village.

For these reasons, multiple-stage "cluster" survey techniques have been developed, in which the population of BSUs is grouped into Primary Sampling Units (PSUs), such as villages. In a two-stage sampling method using villages as PSUs and households as BSUs a sample of villages is first identified, and then, within each selected village, a sample of households is chosen for survey. This approach thus eases the logistic problem of having to visit a large number of villages and a single household in each; instead, one can visit a relatively small set of villages, and then visit several households within each village.

For a representative sample, each household has to have an equal or known chance of being selected. If each village had an equal probability of selection, households living in smaller villages would be overrepresented, by comparison with their prevalence in the population. To ensure a representative sample of *households,* therefore, the sampling of PSUs must be weighted in proportion to their population.

Design effect

The number of households to sample (and hence the cost of the survey) depends on the precision required in the results. The number of households required is also increased in cluster surveys by a factor known as 'design effect'. Design effect depends on the nature of what is being studied, and how it varies within and between PSUs. For example, if everyone in a village is likely to use the same well, access to water supply will vary little within each village. Visiting more than one household in the same village would then provide little further information, and the sample size for a cluster survey would then need to be much larger than that for a simple random sample. Design effect is conventionally set at two when calculating the sample size, but there is reason to believe that it may be much greater for water supply and sanitation (See Appendix A). The Lao survey was the first survey that was designed to measure in a real situation the design effect for water supply, sanitation and hygiene behavior.

The WASH survey protocol requires 32 PSUs (normally villages) to be selected, with a probability proportionate to estimated population of each. The second stage of the sampling process is the random selection of 33 BSUs (households) in each of the 32 villages selected in the 1st stage sampling, giving a sample of 1056 households. The number of clusters or PSUs to be selected is based on analysis of DHS and MICS data (Bostoen 2002; see Appendix A). The sample size makes no provision for non-response or for errors in household listings.
During the data collection all the households in the sample were georeferenced to allow for future geostatistical analyses data clustering which is at the base of these high design effects.

The Laos survey
The survey in Laos used this two-stage cluster design, as shown in Figure 2. The division of the population into PSUs was done along the administrative borders of villages.

At each stage of the procedure, a list is required from which individual sampling units (BSUs or PSUs) can be selected. This list is called a sampling frame. Much of the difficulty of obtaining a representative sample in developing countries is due to the absence of a suitable sampling frame.

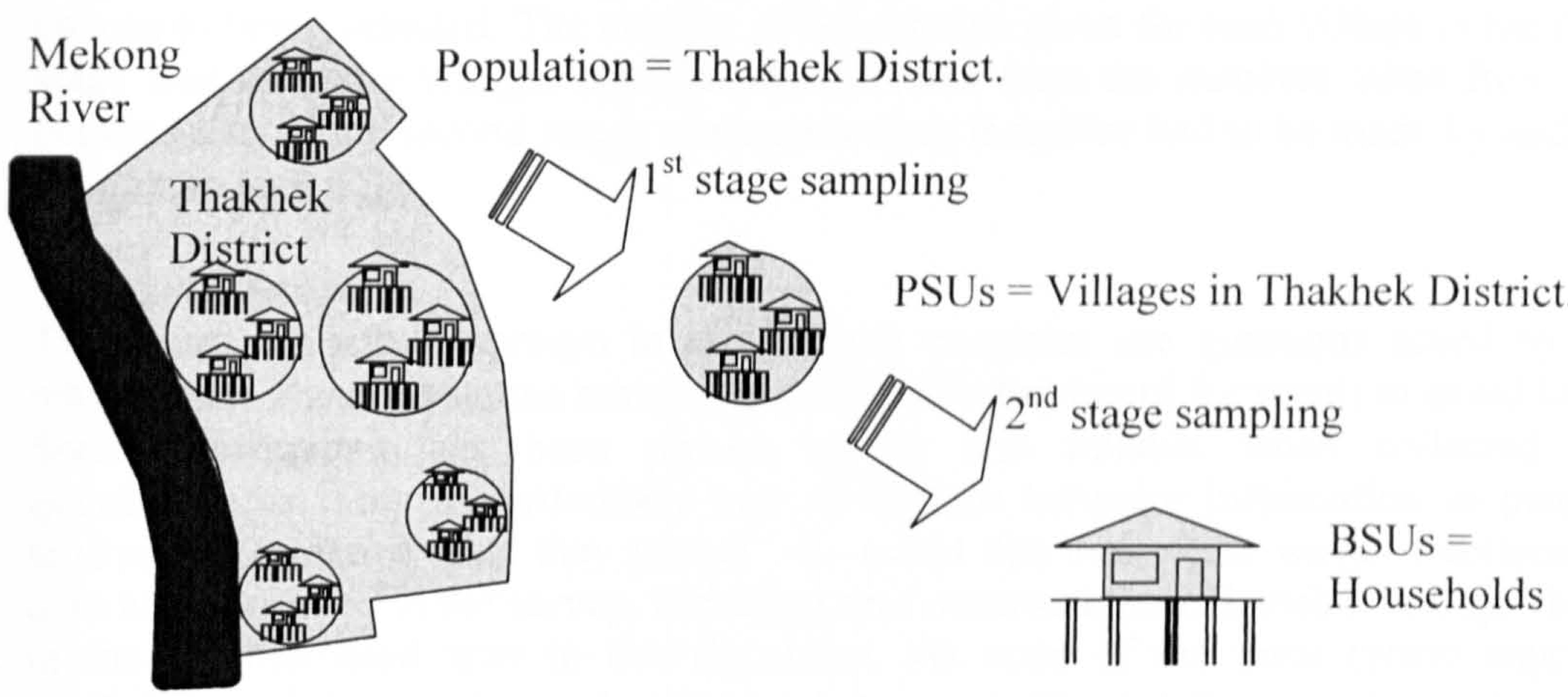


Figure 2: Two stage cluster sampling.

For the first stage sampling, the number of households in each of the 141 villages was collected. This enabled the team to select 32 villages with a probability proportionate to the size of each village. Of the 32 villages, 3 could not be reached during the rainy season. Therefore, an alternative three villages were selected with a probability proportionate to the size of each village from a list which excluded the initially selected villages.

For the second stage, detailed household lists were requested from all the 32 selected villages. From each of these lists, 33 households were randomly selected. Households were identified for sampling purposes by their 'blue plate'[3] (see picture below), although sometimes more one household resides under one blue plate, and some

[3] The blue plate, issued by the central administration, contains the name of the district and village, and the unit and house number

plates are attributed to non-residential buildings. The village authorities also identified households not having such a plate so they could also be included in the sample frame.

The procedure assumed that **all** the people in the district were part of a household that was registered in one of the district's 141 villages. It also assumed that each household was only registered once. Neither of these assumptions could be checked.

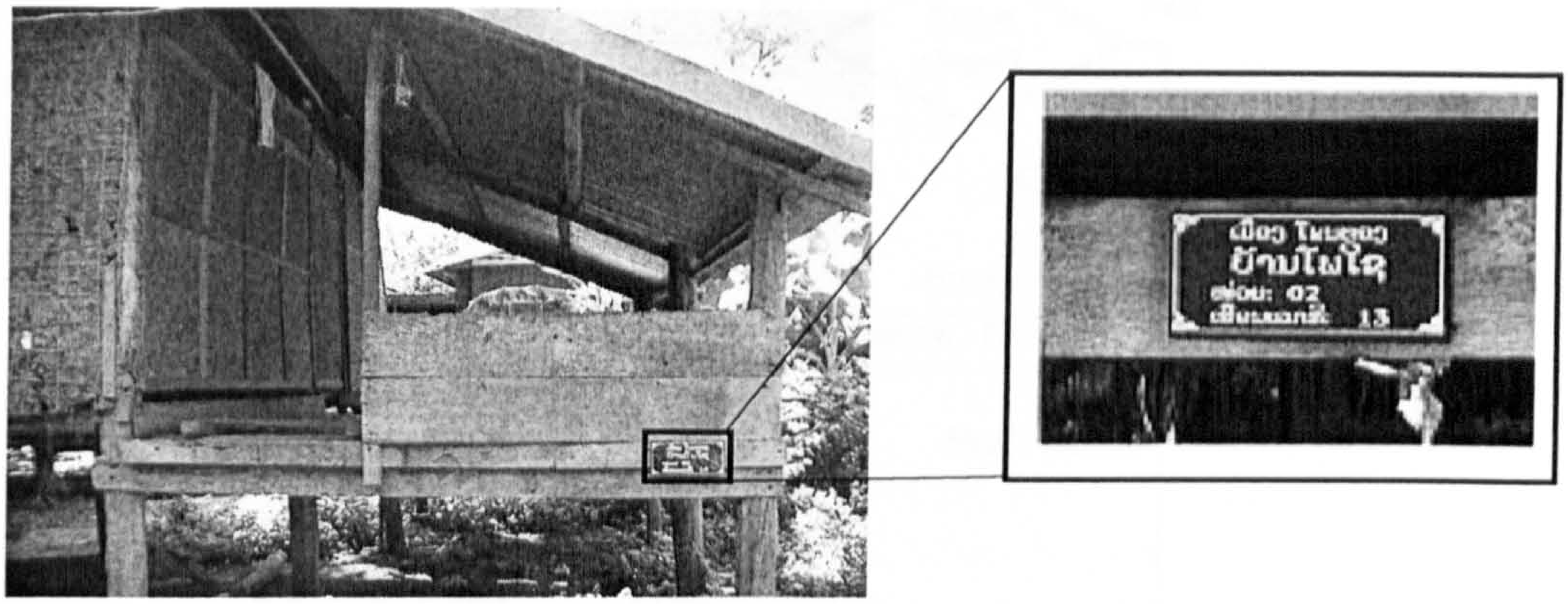


Figure 3: Household Registration Plate (The Blue Plate)

Subject to the assumptions above, this procedure gives each household an identical chance of being selected. The number of households given for each village in the first stage was for some villages significantly different from the numbers taken from the detailed lists in the second stage; some correction therefore had to be made by adding weights to each PSU.

1. 3. 2. Indicators

Traditional household surveys in low-income countries use questions asked by an interviewer. These questions have to be asked verbatim (word for word) to avoid bias. Some information has been proven to be less reliable when collected by questionnaires. This is particularly true of hygiene behavior information as people tend not to 'practice what they preach'. To avoid this bias, other ways of collecting data were explored in the survey, including spot observations and pocket voting. Their merits are discussed later in this document. As none of the three (water supply, sanitation and hygiene) can be assessed by a single question or observation, a combination of factors based on the collected data relates to the indicator of each. These proxies are never perfect, and data were collected to test their validity. Validation is also discussed later in the document.

1. 3. 3. Analysis

Analysis of the data has two components. The first takes the data collected to develop indicators at household level, such as "Access to improved water supply". The relationship between them is predetermined by decision models, as illustrated below. The second part takes the household level indicators data to investigate the properties attributable to the population as a whole. It was planned to use Epi-Info for this analysis, but due to the limitations of this software it could be used only for data entry, and Stata 8 was used for analysis. In future, survey data will be analyzed in CSPro, a freely available program with batch processing capabilities not available in Epi-Info 2002.

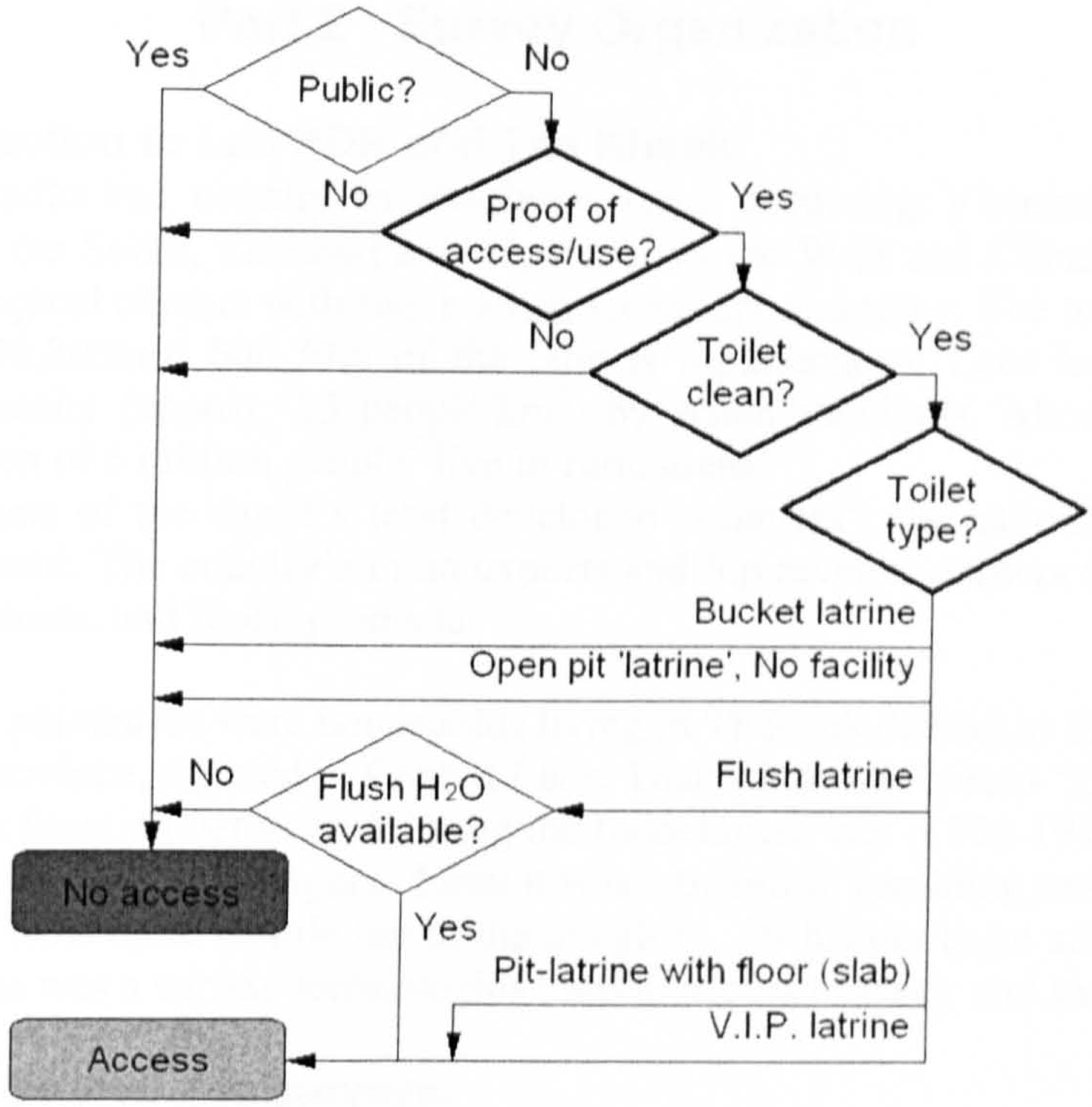


Figure 4: Decision model for access to 'improved' sanitation

Part 2 : Survey Organization

2. 1. Introduction to Lao PDR and Tha Khaek

Laos is a landlocked country in Southeast Asia, bordering Vietnam to the East, Cambodia to the South, Thailand and Myanmar to the West and China to the North. Laos has a tropical climate with two main seasons, dry and rainy. The total area of the country is 236,800km^2 but 70% of the land is mountainous. Laos has a very low population density (approx. 25 people/km^2) by Asian standards. About 85% of the total population of 6 million people[4] live in rural areas.
Lao PDR is one of the world's least developed countries[5]; the national economy is agriculture-based. The country's main exports and top revenue earners are electricity, services, garments, and forest products.

The surveyed population were households living in Thakhek district in the Khammuan Province, situated in Central Laos. Thakhek in Lao means 'guest landing' referring to its function before and during the Indochinese war (1964-1973) as boat landing place for foreign strangers. Later it was a traveling gambling town for day tripping Thai. Now there is little left of the old glory. Its history as an affluent region made that there was a variety technologies used in access to water and sanitation.

Previous estimates and surveys.

According to the UNICEF/WHO[6] Joint Monitoring Program (JMP) the total estimated access to improved drinking water sources in Laos for 2002 is 34%. UNICEF's MICS determined for 2002 that 27% of the Lao have access to improved sanitation, while the WHO figure is 30%. No confidence intervals are mentioned for these figures. More detail can be found in Appendix B.

The 'Statistical Yearbook 2002' of the Lao National Statistical Centre only mentions water and sanitation statistics in Table 74 (pages 103-4), which states details on the 'Millennium Development Goals' (Lao National Statistical Centre 2002) and are summarized below.

Area	Coverage (%)	Sources: UNICEF MISC II, Lao National Statistical Centre (NSC), Committee for Planning and Cooperation (CPC), National Institute of Public Health (NIPH), and Ministry of Health (MoH)
Urban	68	
Rural	19	
Total	38	

Table 2: Proportion of people with access to improved sanitation in Laos, 2000

Area	Coverage (%)	Sources: UNICEF MISC II, Lao National Statistical Centre (NSC), Committee for Planning and Cooperation (CPC), National Institute of Public Health (NIPH), Ministry of Health (MoH)
Urban	75	
Rural	38	
Total	52	

Table 3: Proportion of people with access to an improved water source in Laos, 2000

[4] National Statistical Center, 2002
[5] UNDP Least Developed Countries List
[6] Downloaded from www.childinfo.org, a UNICEF-maintained website, in June 2003.

2. 2. Implementing Agency and Survey Team

The Urban Research Institute (URI) of the Lao Ministry of Communications, Transport, Posts and Construction (MCTPC) and the consultant from the London School of Hygiene and Tropical Medicine (LSHTM) spent a month collecting information in Vientiane and conducting the survey in Thakhek District.

The survey was coordinated by three senior URI staff who where assisted by an advisor from the LSHTM. The survey team consisted of 16 surveyors of which ten were URI staff, three from Thakhek DCTPC and three from Thakhek UDAA. The survey team had been divided into two groups; six people in the survey or interview group, and a further 'observer group' of ten people whose task was validation, described in section II.4.5 below.

2. 3. Survey Site

Figure 5 Thirty Two Selected Villages in Thakhek (Colour Dots) and its location in Lao PDR

Thakhek is the capital district of Khammouan province, located along the Mekong River in the central region of Lao PDR. In the district there are a total of 141 villages, of which 36 villages are in the municipality's area. These 36 villages are also referred to as the urban area of Thakhek District. In 2003 the population of the whole district was 78,577 people according to the 'Provincial Statistical Book'. Of the 36 villages in the urban area, 29 are served by the municipality's piped water distribution network, although the number of villagers that have access and consequently use this network is relatively small (16,908 people out of 30,765 in the 29 villages [7]).

Table 4 contains information relating to use of water supplies and toilets, according to Nam Saat's 'End of Year Report' for the 2001-2002 (Nam Saat 2002).

[7] Provincial Water Supply Authority's Statistics, 2001

	Total	Use clean water		Use a toilet	
	Pop.	Pop.	%	Pop.	%
Province					
Khammouan	310361	174265	56%	85299	27%
District					
Thakhek	75723	56225	74%	39390	52%

(Nam Saat 2002)

Table 4: Prevalence of use of clean water and a toilet in Thakhek for 2001-2002

2. 4. Application of the survey methodology

2. 4. 1. Site selection

Prior to the selection of the survey site, a reconnaissance survey had been carried out. The team coordinating the survey made visits to various districts in the central and southern regions of Lao PDR. Places visited were Paksan in Borlikhamsay province, Outhoumphone in Savannakheth province, Champasak, Phonethong and Pakse in Champasak province and Thakhek in Khammouan province. The aim of the visit was to search for a suitable site for this survey trial in Lao PDR. Suitability criteria were:

- Availability of data to build a sampling frame for the survey area.
- A variety of water sources used for drinking and washing.
- A variety of sanitation solutions applied in the survey area.
- Different levels of wealth of households as well as defined urban and rural areas.
- Willingness to collaborate by the local authorities.

Based on the information collected during the visit it was decided to do the survey in Thakhek. Instead of concentrating on the urban area alone the survey was extended to the district as a whole.

2. 4. 2. Collaboration with local authorities

During the preparations in Vientiane the survey plans were extensively discussed with the National Centre for Environmental Health and Water Supply (Nam Saat) which is part of the Ministry of Health (MoH), and with the Water Supply Authority (WaSA), National Statistical Centre (NSC), WSP-EAP and other organizations. This allowed the team to collect results from former surveys, details on definitions used, and other information and advice for the survey.

During the field survey, the survey team worked closely with Thakhek Urban Development Administration Authority (UDAA), Thakhek Department of Communications, Transport, Posts and Construction (DCTPC), the Provincial Administrative Office and other local authorities such as district office and village elders, or village heads. The survey team was given temporary office space in DCTPC offices for data coding, meeting and daily survey preparation work.

At the start it was made clear that this survey was not linked in any way with possible future interventions. Despite this there was a high level of cooperation and a clear interest from the authorities in the survey.

2. 4. 3. Training for the surveyors

Prior to the survey a three day training of interviewers and observers was organized. Despite differences in training needs, both groups were trained together. This was due to a lack of a skilled observer to prepare separate training for the observers. The training had the following goals:

- Give the participants a history of the project and its relationship with the MDGs;
- Problems regarding current monitoring of water, sanitation and hygiene behavior;
- Goal and methods in the WASH survey methodology;
- Activities involved in validating the methodology;
- Discussion on the methodology as it stands and suggestion for changes;
- Practical sampling issues;
- Translation of the questionnaire into Lao (and back to English as a check);
- Discussion on practical behaviors and problems that might be expected;
- Role-play of doing the survey and simulating potential problems;
- Training on the use of GPSs;
- Pilot testing of the questionnaire;

As the observers only had to do their observations until 1:30 pm it was decided they would also conduct interviews following their daily observation.

The core of the training is the discussion, translation and piloting of the questionnaire. It is clear that most nuances in the English questionnaire were quickly lost in the translation and it is more important to state the exact goal of the question than to propose an exact question to translate. Moreover, the standardization of potential answers is even more important as it constitutes the data from which analysis will be made. Any plausible answer that is not represented in the question might result in the wrong classification of the household if the interviewer is not aware of the issues addressed in the questionnaire.

Spot observations, as used in the survey, are the hardest to standardize between different surveyors and between surveys. For the present survey, this 'standardization' was done by clear descriptions and definition, but it could be extended to the use of photographic training materials adapted to local conditions.

The quality of the training will also depend on the training experience and capacity of the organization, but three days seems to be the absolute minimum duration for the training. During the survey it takes roughly three days in addition to the 3 training days for people to become familiar with what is required. As the data collection takes 10-12 days this is almost one quarter to one third of the way into the survey. It follows that there is an advantage in doing several surveys with the same team to benefit from their experience. It is clear that training costs are almost the same for a small survey as for continuous data collection. Training can be made easier once the WASH methodology is finalized, by the design of adequate generic training materials.
The various forms used can be found in appendixes C to F

Looked at it UNTIL HERE

2. 4. 4. Interview

From the 14th to 25th September 2003 a total of 1056 households in 32 villages were interviewed (See Part I, Sampling). The interviews were mainly conducted by six interviewers. Interviewing started around 7 am and finished around 5 pm every day, including Saturday and Sunday. To speed up the survey the ten people involved in the validation did some interviews after they finished their daily observation.

The average duration of an interview was ±12 min towards the end of the survey. Pocket voting for hygiene behavior was only done when there where at least two people available in the household to do the pocket voting. If only one person was available the questions were just asked. There is a clear difference in interview times between households doing pocket voting or not. During the interview the household coordinates were taken by Global Positioning System (GPS).

Every evening during the survey fieldwork, one of the organizing staff would go through the completed questionnaires, looking for discrepancies or incomplete forms, and consult with the surveyor concerned so see if they still remembered the required information or to make sure they did not make the same mistakes during the rest of the survey.

2. 4. 5. Validation

As mentioned before, there is no gold standard by which to assess the results of interviews. The most reliable way of measuring hygiene is observation. The results of the interviewer and spot observation survey had therefore to be validated by extended structured observations. These were performed by a separate set of field workers, who watched from early morning until early afternoon for various specific behaviors. Some information, such as distance to water source and type of source, is difficult to collect only by household-based observation, so a visit to the source was required to validate it.

Data collection through extended observation takes hours, compared to the minutes of an interview. Only a ten percent sub-sample of households in the sample could therefore be observed in this way, although twice as many field staff were required for the validation as for the survey proper. The ten percent of households (106 households) selected for validation were randomly selected from the survey sample, and divided into two groups, 'observation before interview' and 'observation after interview'. Though the two groups of households were initially equal in number, it was difficult in practice to maintain precise equality. Consequently, the number of households observed before the interview was slightly higher.

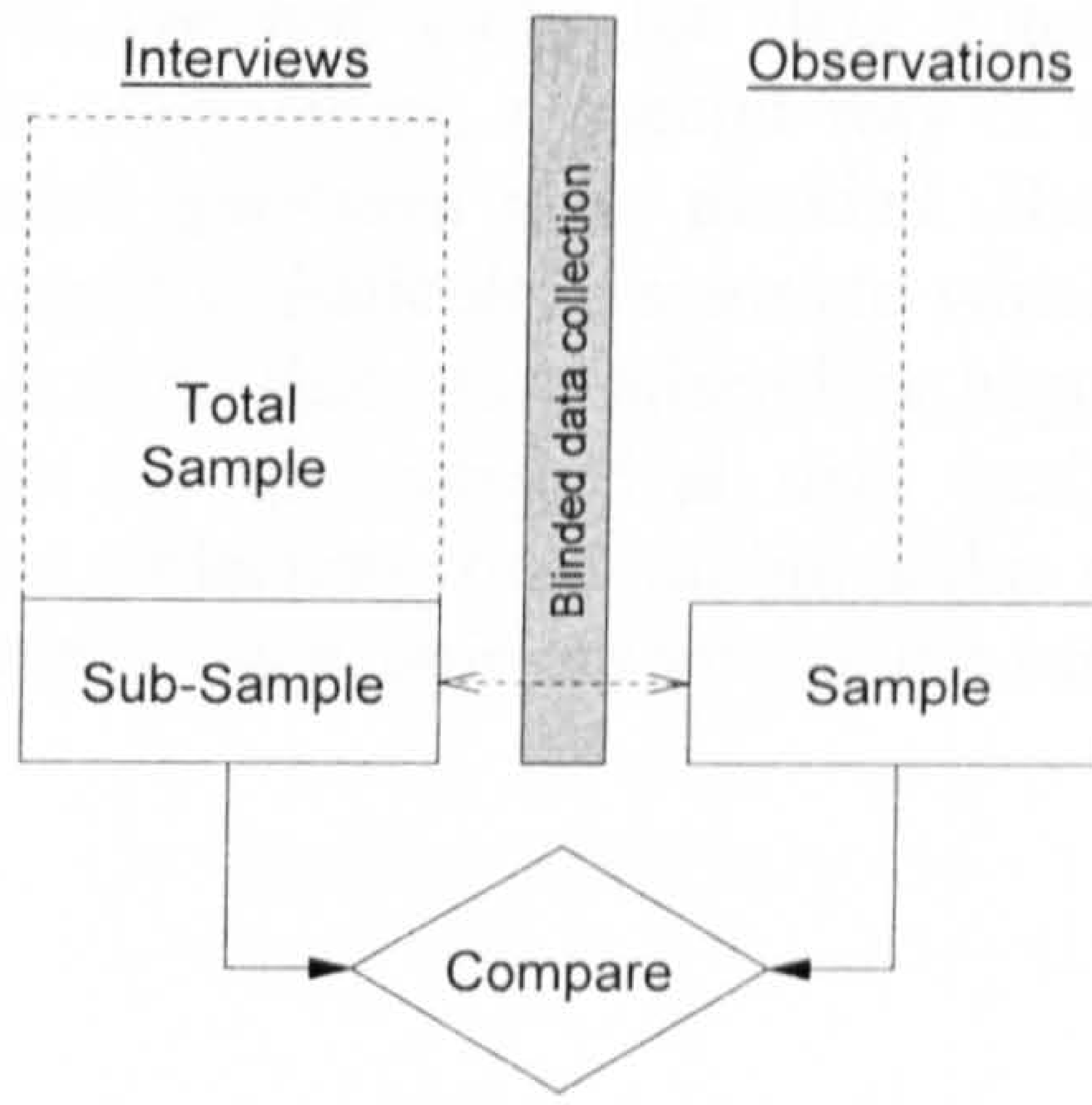


Figure 6: Validation of survey results at household level.

Each of the ten observers was dispatched to a different household each day. Observation started as early as 6 o'clock in the morning and continued until 1:30 pm. The observers recorded activities of household members they observed on a prepared validation form[8]. Appendix E includes validation forms in Lao while Appendix F includes validation form in English.

2. 4. 6. Data coding

The collected information from the interviews was entered on computer on a daily basis using Epi-Info 2002, a windows-based program which is freely available from the CDC website.

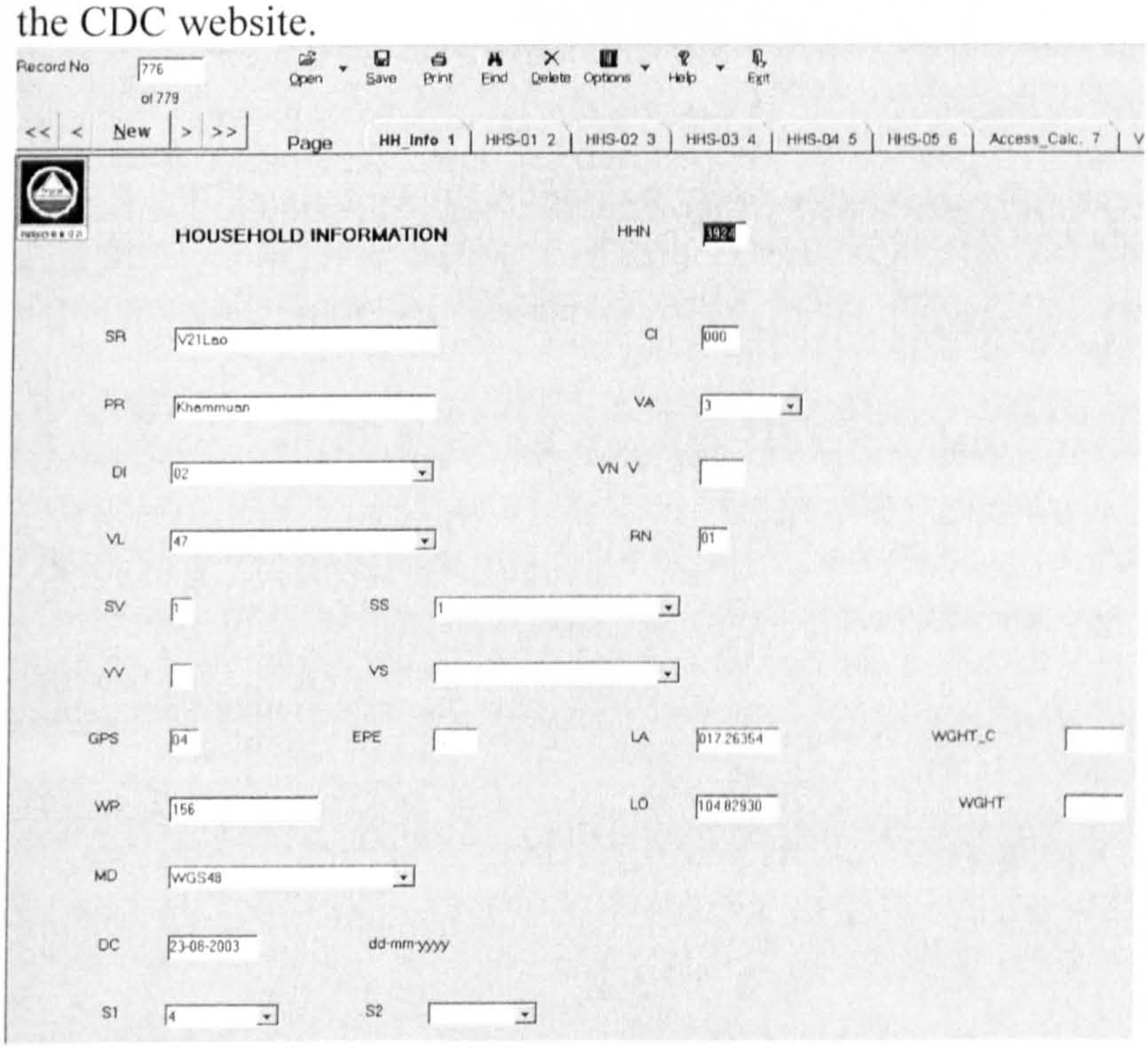


Figure 7: Example of data entry form using Epi-Info.

[8] See appendices for all forms used in the survey

Two or three staff were assigned daily for data entering using three different computers. To avoid data entry errors, a special way of coding was used in which similar codes for successive questions were avoided. Due to limited resources, no double data entry was done. It is difficult to assess to which degree errors were made during the coding but it is clear that more miscoding happened for open codes (any number is allowed) than for the categorical data (only limited code allowed). Technological assisted data collection could minimize this problem but would add the need of a different skill among the people organizing the survey.

Part 3 : Results of The Survey

3. 1. Access to Water

The data collected were analyzed according to the definition used by the Lao Ministry of Health (MoH[9]), the definition used by the JMP in the Global Assessment 2000 Report (GA2000) (WHO/UNICEF 2000) and the WASH definition. The main difference between the definition used by the WASH survey and the other two definitions is that it takes account of collection time, intermittent supply, seasonality and other factors that can influence access. WASH also differentiates between water used for drinking and for hygiene, although they are often the same. The GA2000 and Lao MoH definitions only take account of the type of drinking water.

Access is a binomial variable which has two values 'access' and 'non-access'. In all water and sanitation surveys, exclusion criteria are used to split the households into two groups. The percentage of people having access is calculated by subtracting the percentage of households being excluded from access from 100 percent. This assumes that the definition for non-access is perfect.

$$\boxed{\text{(\% of households having access)} = 100 - \text{(\% of households not having access)}}$$

Equation 1: Access versus non-access

If we consider a third value 'unknown' to this equation to express uncertainties in the definition we could present this value at the intersection of two Venn diagrams as shown in Figure 8.

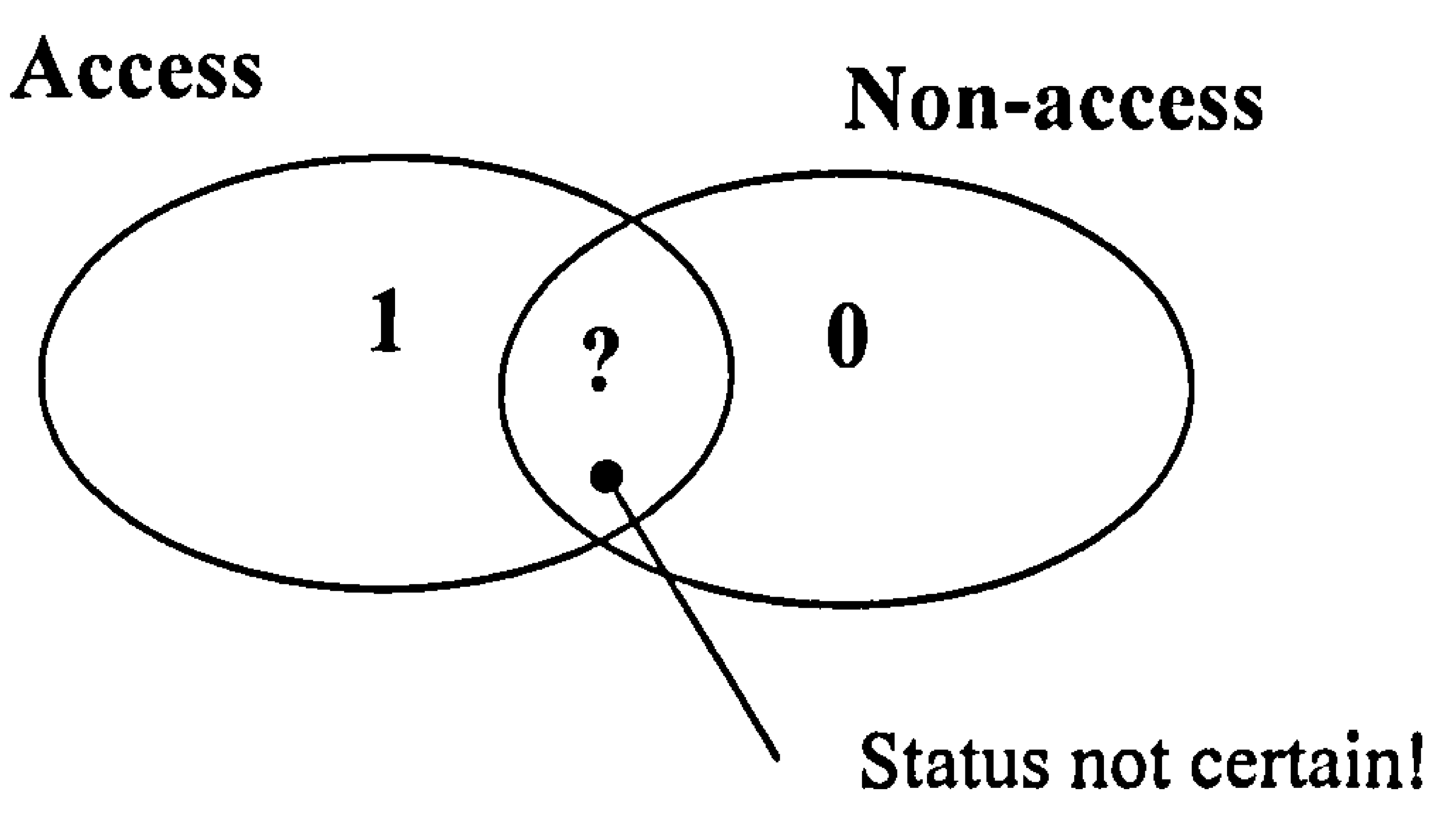


Figure 8: Introduction of uncertainty in the classification of access.

The WASH survey concentrates on signs that accurately indicate non-access to services, such as a water source which is too far away or too expensive. These are *exclusion* criteria relating to access. This means that the area identified by the survey in the Venn diagram is *non-access,* and that we are more certain of this than of access (Figure 9). The survey aims by good exclusion criteria to reduce the number of households in the 'uncertain' area, but as it is difficult to design *inclusion* criteria, the number with uncertain status remains unknown. As long as the uncertainty remains, the tendency will be for surveys to overestimate the number with access. With proper definitions and measurements it should be possible to keep the uncertainty to a minimum, but it underlines the importance of good definitions and measurement

[9] The MoH definition is similar to the GA2000 definition with the exception that bottled water falls under access.

methods.

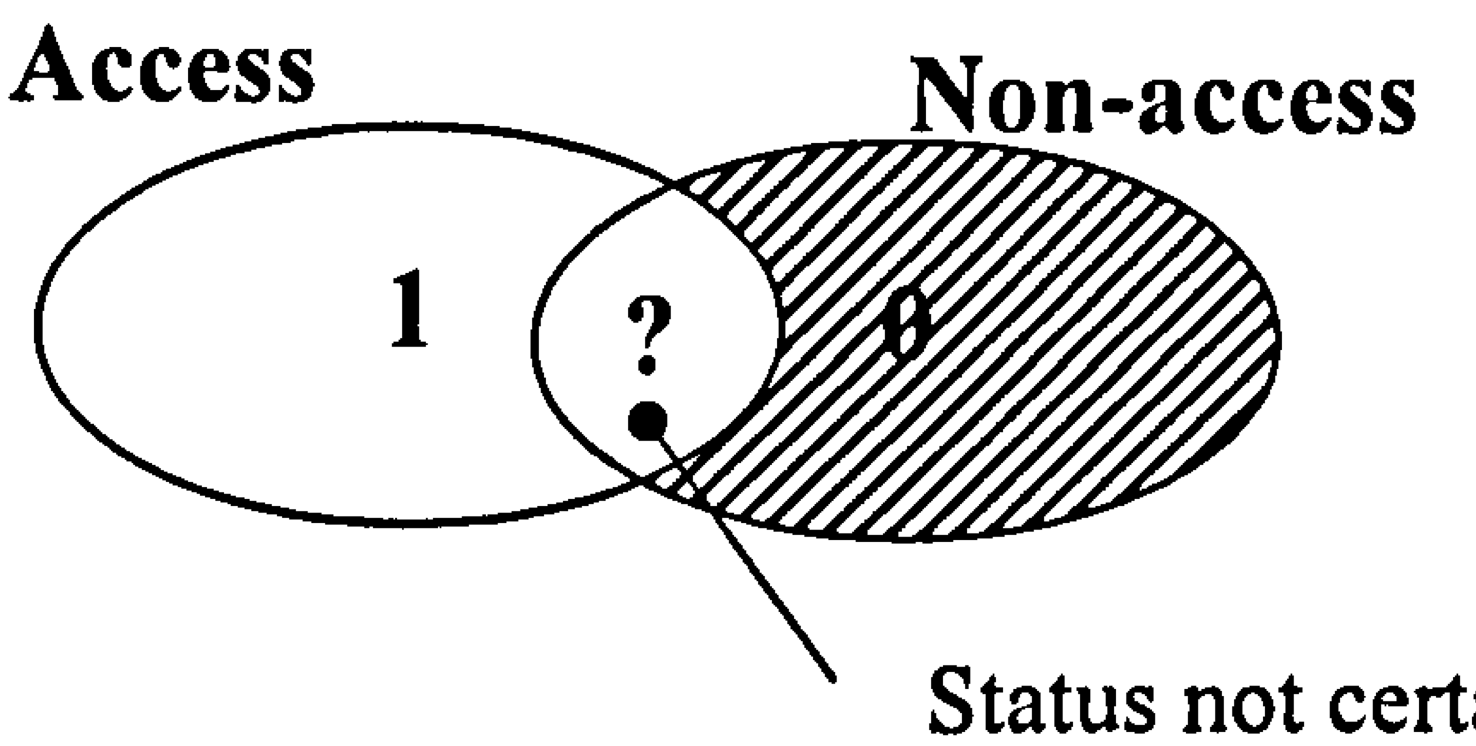


Figure 9: Area in Venn diagram measured by survey.

This report uses figures of non-access rather than access, for two reasons. First, the millennium goals are to halve the number of people not having access to water or sanitation. Secondly, it is easier to design exclusion criteria to access rather than inclusion criteria, so that the data collected allow households to be excluded from access but not included.

Definition	Total (% of household having no access to an improved water source)	Urban	Rural
Non-access GA2000	84 ±7 %	82 ±10%	85 ±8%
Non-access Lao MoH	54 ±8 %	21 ±7%	73 ±10%
Non-access WASH	58 ±7 %	31 ±5%	75 ±10%

Table 5: Households without access to an improved water source, according to different definitions.

The importance of the definition of coverage for the accurate measurement of the coverage rate is shown in Table 5, in which the results of the survey is used to calculate coverage with improved water supply by three definitions; that of the Lao Ministry of Health, that used in the JMP Global Assessment 2000 Report (GA2000), and that used in the WASH survey protocol.

Table 6: GA2000 Definitions of access to improved water supply

Improved water supply	Non-improved water supply
Household connection	Unprotected well
Public standpipe	Unprotected spring
Borehole	Vendor-provided water
Protected dug well	Bottled water
Protected spring	Tanker truck provision of water
Rainwater collection	

Source: WHO/UNICEF Global Assessment 2000

The GA2000 defines access to 'improved' water as shown in Table 6. The difference between the GA2000 and the MoH definition is that GA2000 considers bottled water as a non-improved water supply, on the basis that the price of bottled water will prevent people from buying enough to fulfill hygiene needs. It thus disregards the use of other water sources. The JMP is aware of this restriction in its current reporting. On the other hand, the Lao MoH considers that households using have access to an improved water supply.

Figure 10: Drinking Water Delivery in Lao PDR

In Thakhek District, around 30% of households use bottled water for drinking. The water is delivered to the house in the 18.5 liter bottles which are also used for water coolers. At regular intervals, empty bottles are exchanged for full ones. This service exists in urban as well as in large parts of rural areas. Of the households using this source of drinking water, only 25% are in rural areas while 75% are found in urban areas. Only 12 ±8% of rural households use bottled water compared with 60 ±8% of urban households. The survey data do not show whether this low coverage is due to limited distribution coverage, the cost of the water or other reasons. In the survey, 6% of the people that used bottled water for drinking were classified as lacking access to water, because the delivery of water was not reliable.

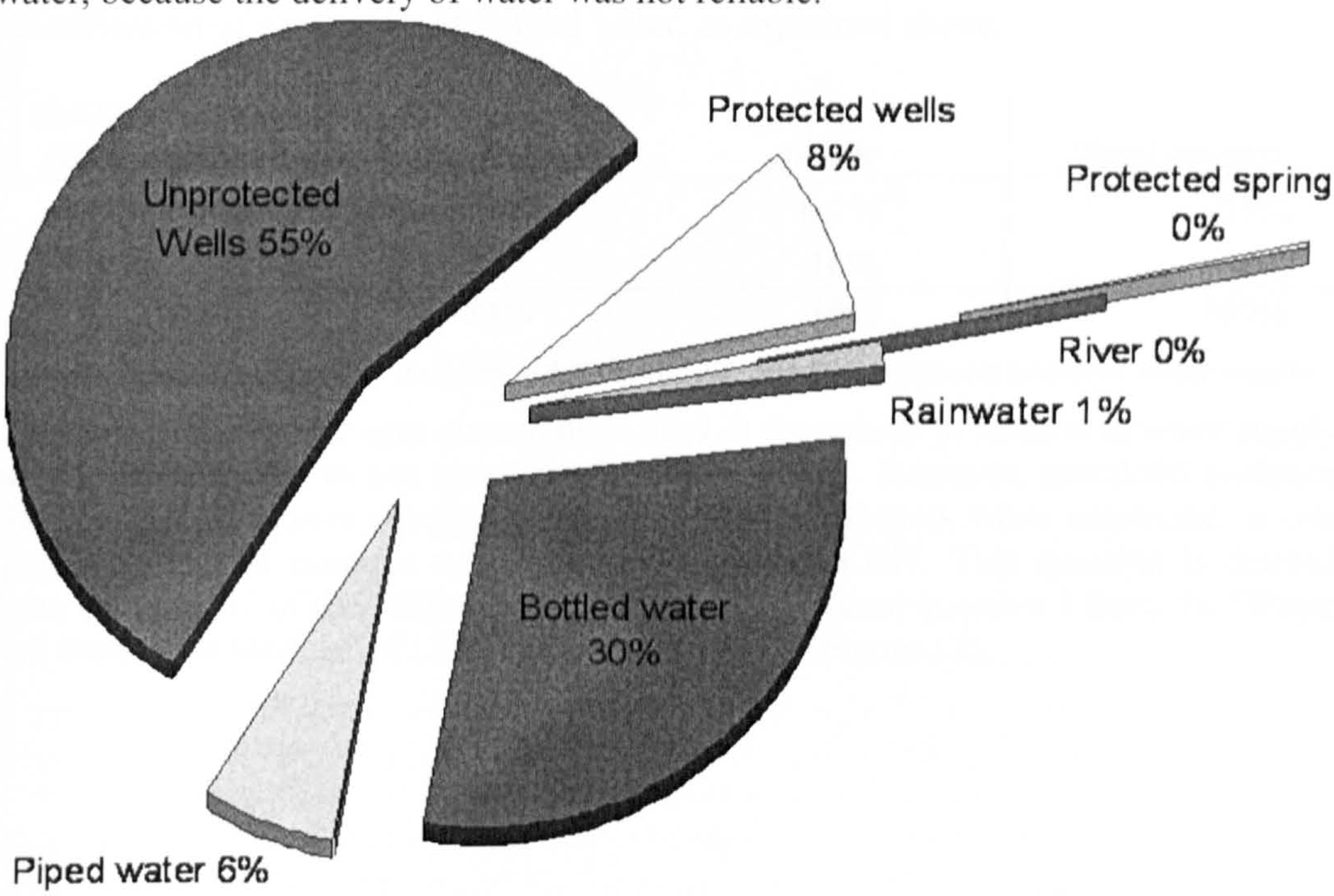


Figure 11: Drinking water sources as reported in Thakhek District, August 2003

Although the WASH definition relies on more household information than the data needed for the MoH indicators, the results are very similar. This similarity is due to a high water table, which enables many households to own a private well. If protected, a well is an acceptable source of drinking water and, if unprotected, an acceptable source of water for hygiene purposes because of its proximity to the household.

Comparing the two different definitions in Table 7 shows us that the criteria in the WASH definition classifies only an extra 1.9% of the sample as lacking access, compared with the MoH definition. This difference is not significant as it is smaller that the confidence interval of ±7% mentioned in Table 5 above. (The small discrepancy between the table below and data presented above is due to the exclusion of households with missing data needed for either definition.)

MoH definition ▶ *WASH definition* ▼	*No Access to water*	*Access to water*	*Total (N=983)*
No Access	54%	1.9%	56%
Access	0%	44%	44%
Total	54%	46%	100%

Table 7: Results Comparison Between MoH and WASH Definitions on access to water supply

In the Lao survey, information was collected on issues such as collection time, intermittence of supply and non-drinking water sources, which were needed for the WASH definition of access. Including these extra issues did not make a significant difference to the measured access rate compared to the definition adopted by the Lao MoH.

On the other hand, the difference between the WASH and GA2000 definitions for access to water are much larger and not negligible. It is due to the different classification of consumers of bottled water, as explained above.

GA2000 definition ▶ *WASH definition* ▼	*No Access*	*Access*	*Total (N=983)*
No Access	55%	0.2%[10]	55%
Access	29%	16%	45%
Total	84%	16%	100%

Table 8: Result Comparison Between GA2000 and WASH Definitions on access to water supply

The main question and spot observations used in the survey in relation to water supply were clear and easy to use according to the surveyors. However, anecdotal evidence showed that surveyors struggled with different descriptions when combined in one question. A good example would be survey question S11. This question is derived from question 21 of the DHS questionnaire and equivalent question 1 from the 'Water and Sanitation Module' of UNICEF's MICS survey (Figure 12).

[10] This percentage is probably due to miscoding errors and still has to be verified.

health risk; however, there is no imminent health risk related to this in comparison to runoff water getting into the well.

According to the Nam Saat 2001/2002 end-of-year report, 74% of the people use clean water; that is, 100% - 74% = 26% do not use clean water. This figure is less than half of the 58% of people without access to an improved water source according to the WASH survey in August 2003.

3. 2. Access to Sanitation

No Laos definition for access to sanitation could be found, so the GA2000 and WASH definitions were used for analysis. GA2000 bases access to sanitation on the technology used, as is done traditionally in household surveys. The WASH survey aims to assess more precisely the likelihood of excreta being hygienically separated from human contact. In the WASH survey tool, this includes assessing the likelihood of toilets being used by all members of the household as well as at different times, for instance at night. The results in Table 9 show figures for non-access, for the same reasons as for water (See III.1 above).

Definition	Total	Urban	Rural
	(% of households having no access to improved sanitation)		
Non-access WASH	59 ±9 %	38 ±10%	72 ±12%
Non-access GA2000	44 ±11 %	16 ± 8%	61 ±16%

Table 9: Households having no access to improved sanitation

The difference in outcomes for the two definitions are represented in the two-way table below (Table 10).

GA2000 definition ▶ *WASH definition ▼*	*No Access*	*Access*	*Total (N=997)*
No Access	44%	15%	59%
Access	0%	41%	41%
Total	44%	56%	100%

Table 10: Comparison of results from different definitions for access to improved sanitation

Table 10 shows that the WASH definition classifies a number of households as lacking access, which had it according to the GA2000 definition. In the Lao survey for example, 42 out of 144 households with flush toilets were classed as without access on the basis that their toilets were too dirty to segregate faeces safely from human contact as described in the definition. The survey did not collect analytic data to determine why the toilet is dirty. These 42 households represent 28% of the households classified differently by the two definitions, and 29% of the households with flush toilets.

The exclusion of 29% of the flush latrines seems to be high and was extensively discussed with the surveyors. Although we agreed that this figure is probably right, it indicates potential problems with spot observations as a judgment is involved, which might differ from surveyor to surveyor.

The Lao survey confirmed that ownership of a toilet is different from use. Anecdotal information confirms survey data that in rural areas, people often fail to use toilet facilities at home and prefer to go in the woods and fields.

The two main types of anal cleansing materials used in urban Laos are paper and water. Often paper will be disposed of, not in the flush latrine but in a bin to be collected and disposed of through the central solid waste collection system. These cleansing practices are also followed in rural areas, although there is no reliable solid waste collection system. Anal cleansing material was not identified as an issue before the survey, so no data on this subject were collected.

Table 11 examines whether people having access to sanitation also have access to water. There is a consensus that for health benefit the two conditions should be fulfilled. In fact, only 14% of the households in our survey had access to water and to sanitation, 42% had access to water but not to sanitation and 27% had access to sanitation but not to water.

		Access to water		
		No	Yes	Total
Sanitation	No access	17%	42%	59%
	Access	28%	14%	41%
	Total	45%	55%	100%

Table 11: Relationship of access to improved water and to sanitation

3. 3. Improved Hygiene Practices

In the Lao survey, hygiene practices proved to be the most difficult to measure. Pocket voting, which had looked promising in the pilot survey in Kenya, seemed not very useful in Laos. In contrast with Kenya, the observed presence of items needed for hand washing (soap, water and a basin or tap) seemed to work far better, and the presence of soap was less ambiguous because people in Laos distinguish between bar soap used for hand washing and the powdered soap they use for washing clothes.

'Hand washing' without soap is very common in Laos; even the survey team would rarely use soap when washing their hands. The question used in the survey did not enquire explicitly enough for hand washing with soap. Soap (or another cleansing agent) is needed to provide an effective barrier to fecal-oral transmission of disease, not so much due to the action of the soap as a product but more due to the greater efficiency of hand washing when such agents are used.

The hygiene indicator was based on different questions, observations and pocket voting. The WASH draft protocol defines the indicator of good hygiene practices if two-thirds of the questions being answered demonstrate "good" behavior and at least 3 different questions answered or observations made. This resulted in only 10% of households being classified as not having good hygiene practices. This result is generally considered too low to correspond with the reality of Thakhek District. Of all the indicators tried in the survey, the presence of soap, water and a basin or tap seemed to be the best alternative indicator. This would have classified 71% of households as not applying good hygiene practices.

To measure this indicator more creative thinking is needed and much more work before a reliable indicator can be developed.

3. 4. Validating the survey data

Despite the successful collection of validation data trough structured observation the results of the validation work have proved unexpectedly difficult to analyze and were not ready in time to be included in this report.

3. 5. Fieldworkers' meeting, and 'Focus Group Discussion'

At the end of the trial survey, all the fieldworkers met in Thakhek to evaluate the survey methodology, look for problems and discuss potential solutions. Many surveyors suggested the use of clearer and simpler questions to allow a better understanding of the issues covered, make them more practical to use and easier to translate. They also suggested a whole day for evaluation during the survey period, instead of daily evaluations every evening after the fieldwork when they were already tired. Surveyors also agreed that observation was the most difficult part of this survey.

In addition, one randomly selected villager from each village in the sample was invited for a focus group discussion. The discussion sought to gain an insight into their perception on data collection. Towards the end the preliminary results of the survey were discussed. After the focus group discussion, preliminary results were communicated to the villagers present, and to the village and district authorities.

Like the extended household observation, focus group discussion was a completely new approach to data collection for the survey team. Their lack of experience in these approaches complicated the data collection, although the observations were structured and simplified by using a marking sheet. The extended observations are part of the validation and will consequently not be included in the final survey design, while spot observation will be.

According to the survey team the participants in the 'focus group discussion' said little except to agree with the result and request further assistance. Villagers are unaccustomed to discussing such issues with officials, but their reticence could be due still more to the way the discussion was organized. The villagers were led into a big hall with the dignitaries upfront, and had to talk through a microphone to address those present. This was hardly conducive to the 'safe' environment in which people can openly speak and discuss as normally created for such events.

Some of the points made in the discussion were:

- Having a toilet facility in rural areas does not mean it is used, as often people still prefer the woods if they have that option.
- Soap is rarely used for hand washing, particularly in rural areas.
- For the people from the various villages, this was the first time they were given the opportunity to address these issues in the district capital, and this was highly appreciated.
- The results given were accepted although there was little scrutinizing of the results.

Part 4 : Discussion and Recommendations

4. 1. Implementation of the Survey

Timing and staff requirements

The timing for the survey, held during the rainy season when URI has less workload, was not ideal. Some villages were inaccessible, and others took up to an hour to reach. Nevertheless, the survey as a whole was quite successful as it was finished in time and fulfilled its objectives. Because the villages that were difficult to access were small and they were selected with a probability proportionate to size, only 3 villages had been selected which could not be reached, and they were successfully replaced by 3 other randomly selected villages.

Determining the number of days and of fieldworkers needed for the survey was based on an estimated requirement of 60 min per household, including traveling time from household to household. In the pilot test in a Kenyan informal settlement, only half this time was needed. In the Lao case the spread of the households within the PSUs was large, and the interviewers had to walk up to 20 minutes from one household to another.

Although in the afternoon of each day the interviewers got some help from those validation observers who had finished their extended observation earlier, the help was not so reliable since the observers were not so familiar with the interview forms (especially in the first few days) and had to rely on the surveyor's GPSs for mapping the survey.

Moreover, the survey proved, according to the implementing organization, to be labor-intensive (One observer per household per day), tiring (12 straight working days from very early morning till late evening doing exactly the same things) and a substantial budget is required for such a brief activity. More than half of the budget was allocated for the validation.

Data collection times:

The contact time with the interviewers in the Lao survey changed gradually from an average of 23 minutes on the first day to 12 minutes toward the end of the survey. This compared with the Kenya urban survey, where the collection time fell from 30 minutes on the first day to 10 minutes three days later.

As the questionnaire still contains extra questions and observation tasks which are included for testing but can be removed in the final version, it seems feasible to design the WASH survey in such a way that in its minimal form the contact time at the household will average no more than 10 min.

Time of data collection.

The best time to find people in the household is early morning and late evening. Early morning seems to be the best time to find people at home. This makes the working hours for the survey team quite long. There is also the time needed to go to each village in the early morning and return from it in the late evening. This was similar to the experience in Kenya, though it was not possible to be early or late in the informal settlement in Kenya due to security constraints. This was one of the major causes of the high non-response rate in the Kenya survey.

Most people in the study area live in a subsistence economy and have to work at weekends. Although response rates were higher at the weekend in Laos (and in Kenya), it was still difficult to reach all the selected households by only including these days. Thanks to the extraordinary cooperation of the surveyors, it was possible to reduce the number of non-responsive households in the survey to four households. This excludes units that were selected but did not contain households, such as commercial premises or destroyed houses.

Sample frame

The surveys in Kenya and Laos both found that information existed to build a sample frame. In Kenya these were lists of 'plot owners' with the number of rooms on each plot, while in Lao these were the 'blue plates', updated with information from the local authorities. Even if these sample frames were not perfect and could be improved, a more regular update of this information could be useful. In both cases, regular updates of this information would improve these sample frames considerably at a very low cost despite the fact that this information is initially kept for other purposes.

Resources needed for the survey

In terms of human resources for the survey:

- Six surveyors covered 1056 households in 12 days – an average of just under 15 households per day for each of them, which is similar to the productivity of national census enumerators in developing countries. It would have been preferable to plan on the basis of 10 households/day/surveyor.
- Two supervisors doubled for data clerks although separate data clerks would have been better.
- One driver with minibus.

In terms of human resources for the validation:

- Twelve observers. In the Lao survey, the observers joined the survey team after they finished their work, but that proved not to be a good idea.
- One extra supervisor.
- One extra driver with minibus.

These requirements are in addition to the management and technical input required. One experienced technical professional is needed full-time for at least a month to manage the field work. Where the survey is being implemented for the first time, an external consultant may also be required for technical support and training.

In terms of finances, administrative and human resources and transport costs determine the cost of the survey.

- For transport, one should allow for roughly 4 return trips to each cluster on top of the cost for the travel of the whole team and equipment to the survey location;
- Administrative costs are mainly 6500 photocopied pages for the survey and 500 for the validation.
- Telecommunication costs –telephone, fax and especially mobile phone costs – add substantially to the administration budget;

- Fieldworkers are needed for roughly two weeks including training, although for budget purposes it is best to plan for 20 days.

In terms of time, the whole data collection process in the field takes about a month.
- Two weeks preparation.
- Two full weeks (3 weekends included) for training, data collection and data entry.
- A further week is needed by the survey manager to calculate preliminary results and for report writing.
- An extra month minimum should be included in future for one statistician to do further analysis on the data set.

The time needed to do the analysis was hugely underestimated in the Lao survey so that this part of the work is still in process.

Design effect and its consequences
Design effect is a figure that determines by which factor the sample size will have to be increased in a cluster survey compared to a random sample to obtain the same precision. It can only be determined in a real cluster survey. This increase is due to clustering of the survey which is needed to make the data collection both practical and economical. When the design effect is unknown, the general consensus is that a figure of two should be used in calculating the sample size (Bennett 1991). However some types of information like access to water and sanitation may have a far higher design effect.

The Lao survey was the first survey that was designed to measure in a real situation the design effect for water, sanitation and hygiene behaviour. Previous work (Bostoen 2002; see Appendix A) had only measured design effect on existing data sets. The results indicated that design effect for access to water and sanitation after stratification was around 7. The survey in Laos found values of 13 when no stratification was used in the analysis and 6.5 when stratification was used to separate urban from rural areas in the analysis. This is line with the findings of theoretical studies of DHS and MICS surveys.

High values of design effect for a purpose-designed survey like the WASH survey have the following implications:
- Sample sizes for water and sanitation surveys will be high – typically over 1000 households, because for a given precision, sample size is directly proportional to design effect. Sample size has a direct influence on the survey costs.
- The minimum number of clusters for the survey will be high – more then 30 – which also affects the survey costs.
- In some small surveys, it will be cheaper to apply simple random sampling; it will be important to find a rule of thumb to determine when this is the case.
- Alternative survey designs without a sample frame could be more cost effective if they reduce the design effects. These might include random geographic point (sticking a pin in the map), or clusters of multiple adjacent villages. However they still need to be developed.

4. 2. Discussion and Recommendations on Methodology

4. 2. 1. Survey

In the evaluation after the survey we did some pocket voting and got some worrying responses (Table 13). It is not clear if it was mainly observers or interviewers (10 Observers and 6 Interviewers) who 'made up' information or if the information 'not collected' was related to more difficult questions or observation, not all of which was used for the summative analysis or validation. The information below thus has to treated with some caution.

Did you ever fill in information (invented information) that was not collected through interview or observation?

ANSWER:		n	%
I fully made up some of the information		0	0%
I often made up some of the information		4	27%
I sometimes corrected some forms with uncollected data		1	7%
I never made up any information		10	67%
	Total:	*15*	100%

Table 12: Surveyors' Evaluation Questionnaire

Some other studies doing similar analyses will have to be found to put this in context but anecdotal information seem to indicate this is not unusual. The question is how to deal with it.

4. 2. 2. Data entry

Data entry is a long and tiring process, which is not always done with sufficient rigor. So even if the data are collected well they might not be entered correctly into the computer. Using new technology, for example IT assisted data collection with PDAs, might help to obtain more reliable data and increase people's willingness to do surveys. However, it would add another layer of complexity to the survey. It would also require those conducting survey to have the extra skills required to manage these systems. The system with different codes allowed for relatively correct data coding. Household and form numbers were often mistyped resulting in problems for analysis in Epi-Info when the various data sets from different computers were merged. Using barcodes in the future for this type of data might be a solution to this problem. However this requires again different skills and technologies.

4. 2. 3. Data analysis

Although analysis in Epi-Info should be possible in the future it proved to be hard to achieve in this survey. In the end we used Stata_8 (a commercial statistical package) for data cleaning, which was virtually impossible in Epi-Info_2002. Stata_8 and SPSS_11 analysis as SQL script used in Epi-info 2002 could not deal with what it calls 'complex' expressions.

For the future, SCPro 2.4 might be the solution to this problem. It is a freely available software package developed and used for DHS surveys and by the American census office

4. 2. 4. Sampling

We have some interesting information on sampling in relation to water and sanitation but it is rather technical. What is clear, however, is that the design effect is much larger for water and for sanitation than the default value of 2 commonly used in the design of cluster surveys. This means that roughly 7 times more households are needed for conventional two-stage sampling than for a simple random sample of the whole population.

This does not mean that the survey is 7 times more expensive. For a survey at national level, where the cost depends largely on the number of clusters to be visited, the WASH 32 x 33 design could cost only one quarter as much as a simple random sample of the same precision. At the other extreme, it is probably cheaper to do random sampling in smaller surveys like 'small' districts and certainly small towns and villages. Further analysis of various survey costs is needed to determine the cutoff point.

4. 2. 5. Validation

Structured observations were very difficult to do. The major problems encountered were the lack of skilled and experienced observers, and the Lao culture, which does not easily accept people observing in the household. Also to shape structured information data into indicators proved to be much more difficult than expected and the results could not be made available for this report.

The main result of the survey, the rate of access to improved water sources, is in line with the data collected by the District Statistical Office. For sanitation, no existing data were available for comparison, but the different definitions used seem to indicate that the WASH survey gives a more representative result.

Hygiene behavior proved difficult to measure. Based on various surveys the presence of items for hand washing seems to be the most reliable proxy for hygiene behavior, but we have no gold standard with which to compare it. It was hoped to use the extended observation data as a means of assessing the predictive value of this and similar indicators, but those data have a number of shortcomings arising from the manner in which they were collected and recorded in the Lao survey. It is hoped to analyze the data in the near future to assess how reliable this indicator is. However the detailed method of assessing the presence of hand washing items needs more work to increase it reliability.

Appendix A Sample size determination for testing the WaSH indicators

The simple random sample is the gold standard in sampling, and if a simple random sampling is to be used to determine the proportion in the target population, the sample size needed can be calculated with the following equations.

	Exact	Approximate
Sample size for proportions with relative deviation	$n \geq \frac{Z^2 N P_x(1-P_x)}{(N-1)\varepsilon^2 P_x^2 + z^2 P_x(1-P_x)}$	$n \geq \frac{z^2(1-P_x)}{\varepsilon^2 P_x}$
Sample size for proportions with absolute deviation		$n \geq \frac{z^2 P_x(1-P_x)}{d^2}$

z Reliability coefficient or amount SE away from the mean
n Sample size
N Population
ε Relative deviation (%) of the result, εP_x= d, Absolute deviation of the result
d Absolute deviation (% points) of de result or PRECISION
P_x Unknown population proportion for sampled variable

(Lemeshow 1990; Levy 1999)

Equation 2: Sample sizes in simple random samples

The maximum sample size needed for a simple random sample with a precision of 10 % points would be when $P_x = 50\%$. The sample size needed would be 96 basic sampling units as calculated in Equation 3.

$$n = \frac{z^2 p(1-p)}{d^2} = \frac{1.96^2 \times 0.5(1-0.5)}{0.1^2} = 96$$

z=1.96 Reliability coefficient or amount SE away from the mean
d=0.1 Absolute deviation (% points) of de result or PRECISION
n Sample size

Equation 3: Simple random sample size calculation

Simple random sampling is unpractical and costly for use in a large scale population survey because individual sampled units can be many kilometers apart. That is why multistage cluster sampling was developed. There are many different designs for multistage cluster sampling surveys. The method used in the WASH survey is explained below

Multistage cluster sampling.

Multistage cluster sampling splits the selection process into multiple stages; at each stage different selection procedures can be used to select various subsets until the BSUs are selected. A commonly used and simple design for a two stage cross sectional survey is to select the primary sampling units (PSUs) with a 'probability proportional to size'. The second stage is typically a random (or pseudo random) sampling of equal size in each of the selected PSUs. It can be proven mathematically that in this way all the BSUs have an equal non-zero chance of being selected. This type of sampling is referred to as a self weighted sample or an equal probability of selection method (EPSEM) because no weights have to be given to the individual samples or PSUs. The number of samples selected in the cluster, also referred to as 'take', are for each cluster the same which results in a simple self weighted sampling method.

There are however limitations to this way of sampling:

- The measure of size used for the PPS sampling of PSUs can be different from the BSUs. E.g. if the BSU is children between 12-36 months the number of children for each PSU might not be known. The number of households could be taken as a measure of size on the assumption that there is a linear proportional relation between the number of BSUs and the measure of size.
- Often, estimates of size are used rather than the known size, which can reduce the statistical validity of the sample result. The method is referred to as the selection wit probability proportional to the estimated size or PPES instead of PPS.
- If the survey population is not homogeneous (it rarely is) there is the possibility that some PSUs group BSUs together which have a particular value. This clustering increases the possibility that the survey values are not representative for the population. This uncertainty, expressed as the design effect, will increase the variance of the survey measurement.

The increase in the variance is expressed by a factor D called the design effect (deff) ratio.

Including the design effect the equation for the standard error becomes:

$$\hat{s} = \sqrt{\frac{\hat{p}(1-\hat{p})}{n}\hat{D}} \quad \Rightarrow \quad n \geq \frac{p(1-p)}{s^2}\hat{D}$$

(Bennett 1991)

In a cluster design the sample size has to be increased with the design effect to result in a similar standard error as a SRS

s standard error SE — D design effect (deff) — p proportion

$\hat{s}$ estimated SE — $\hat{D}$ estimated deff. — n sample size

Equation 4: Standard error and sample size in cluster sampling

Design effects and rate of homogeneity

Among diverse selection procedures the chosen selection method has by far the greatest effect on both the variance and the cost (Kish 1965). Samples obtained through cluster sampling cannot be directly calculated with Equation 2. Cluster samples are characterized by a higher homogeneity than simple random sample in the same population which tends to increase the variance of the sample. Generally cluster samples have a larger standard error which requires them to have a larger sample to obtain similar standard errors as if simple random sampling were used. The factor expressing this difference is called the design effect (Deff). *Design effect* are defined as '*the ratio of the actual sampling variance to the variance of a simple random sample with the same number of units*' (Yates 1981).

$$Deff = \frac{\text{actual sample variance}}{\text{variance of a random sample with the same number of basic sampling units}} = \frac{V_{cs}}{V_{srs}}$$

Deff. design effect
V_{cs} Variance of the cluster sample
V_{srs} Variance of a simple random sample with the same number of BSUs in the same population.

Equation 5: True design effect

In reality we can only work with information from our sample. Moreover we do cluster sampling to avoid having to take simple random samples from the population. Without a simple random sample for comparison, the true design effect would be only a theoretical concept. However, in practice, the design effect is calculated as '*the ratio of the actual sample variance as cluster sample* to *the variance of the same sample calculated as if it were a random sample*'. This gives us an idea of the possible true design effect, which in real sampling will stay unknown.

$$deff \cong \frac{\text{cluster sample variance}}{\text{variance of the same BSUs calculated as a simple random sample}} = \frac{\hat{V}_{cs}}{\hat{V}_{srs}}$$

Deff. design effect
V_{cs} Variance of the cluster sample
V_{srs} Variance of the same sampled BSUs calculated a simple random sample.

Equation 6: Practical calculation of design effect

Design effects express partially the clustering of the measured characteristic in the population. This effect can be reinforced or attenuated by the clustering of the samples. Design effects are empirically obtained through a survey of a similar design. What exactly has to be similar is not clear from literature but the take size (average numbers of samples in each cluster) and the number of clusters seem important factors in the design of a two stage cluster sampling. To have a better insight into the 'typical' design effects for access to water and sanitation, data from some existing DHS and MICS data sets were analyzed. The introduction of a generalized intra-cluster correlation coefficient , termed "rate of homogeneity" (*roh*) by (Kish 1965) aims at removing the effects of average cluster sizes in the comparison of results across different variables and population domains.

$\hat{deff} = \frac{V_{cs}}{\hat{V}_{srs}} = \frac{V^2(\hat{\bar{X}})}{\hat{S}^2_{srs}/m} = 1 + \rho(\bar{b}-1)$ (du V Florey 1993; Kish 1965)	$\hat{\rho} = \frac{\hat{Deff} - 1}{\bar{b} - 1}$ (Kish 1965)

deff. design effect
V_{cs} Variance of the cluster sample
V_{srs} Variance of the same sampled BSUs calculated a simple random sample.
S_{srs} Standard error of the same sample, calculated simple random sample.
$\hat{\bar{X}}$ Estimated mean of the measured variable
S_{cs} Standard error of the cluster sample
m sample size
ρ rate of homogeneity *roh*[11]
b take or cluster sample size

Equation 7: Design effects and rate of homogeneity *roh*

(Montanari 1993) looked at how valid ρ was in expressing the rate of homogeneity within the population rather than within the sample. He found that the ρ will only do this under certain conditions and states that there might be better indicators for this. To do this he introduced a variable *k* as shown below.

$$\hat{deff} = (1-k)\left[1 + \rho(\bar{b}-1)\right] \quad \text{with} \quad k = A_{D0} + A_{D1} + A_{D2} + B_{D1} + B_{D2}$$

(Montanari 1993)

Equation 8: Variable 'k' in the relation between deff and ρ

The formulae for each of the factors determining *k* are relatively complex and theoretical but (Montanari 1993) states that under particular circumstances k becomes negligible and Kish formula becomes valid.
For dichotomous variables these conditions are:

- *Allocation of PSUs to the strata is proportional to the stratum sizes.*
  The designed survey methodology will only apply explicit stratification which means that for each stratum (e.g. Rural, Urban) a separate survey has to be done. This means that each survey only has one strata and this condition is in our methodology fulfilled at all times. Based on the results of the WaSH survey trial in Laos (Jul 2003) this might need revision.

[11] In literature the abbreviation 'roh' for rate of homogeneity and 'rho' for de Greek letter 'ρ' are both used to denote the generalised 'intra-cluster correlation coefficient' ICC.

- *The PSU selection probabilities are proportional to the domain sizes and the population is the domain.* In the survey no data is provided for the analyses of different domains so the population is the domain, which together with PPS selection of the PSUs provides a partial condition for k to become negligible.
- The last condition to use Kish's formula is that the sampling in the survey is self-weighted (EPSEM) which it is.

In the WASH survey the conditions for $k \approx 0$ will therefore be fulfilled. This means that we will use Equation 7 as initially formulated by Kish (1965). Moreover including k would increase the statistical complexity dramatically without clear benefits. To keep the statistics in the survey method simple we will follow the suggestion of Kish (1965) to use empirical studies to improve the estimates of *deff* using the rate of homogeneity ρ as defined in Equation 7.

(Thomsen 1986) looked at the effect of using an out-of-date measure of size in determining ρ and noticed that the differences can be considerable. This is not so important for the WASH survey and its analysis but very important for the abstraction of ρ from new or existing surveys where the measurement of size used might not be correct. The ρ will vary between a maximum of one for high design effects and 0 for none. Roh can occasionally become negative if clusters result in a lower variance than in simple random sampling. This situation is however exceptional.

Existing data collection, MICS, DHS

To estimate design effects and the rate of homogeneity ρ some DHS and MICS datasets have been analysed. The datasets used were DHS for the Dominican Republic 1994, DHS Kenya 1998 and MICS Moldavia 2000. After the cleaning of the data a new binary value was created representing access to an 'improved water source' based on the information available in the DHS and MICS data sets. As water, sanitation and hygiene data are collected as an extra add-on to these surveys the non-response to these questions can be high. This non-response is considerably higher for sanitation and hygiene behavior. The DHS for the Dominican Republic 1994 was chosen to calculate ρ as out of all the datasets analysed it had the lowest non-response ratio (13%, n=8830) for access to water. The data set was the only one that contained information on drinking and non drinking water, which made possible to create better access indicators. Water is expected to have the highest design effects because it has a geographical determinant (the distance to the source) to it. This is demonstrated in Figure 13 by an example of an EPI sampling, a simplified sampling used in the UN 'Enlarged Program of Immunization'. *The method uses a random direction from a central point by e.g. spinning a bottle. The households in that direction are listed from which one is randomly selected. The sample is selected by taking each time the household closest to the last eligible household.* Geographical determinant, like distance to source, are the reason why high design effects are expected for the access to water indicator. The dataset yielded a design effect ratio for access to water indicator of 7.5. This result in a rate of homogeneity:

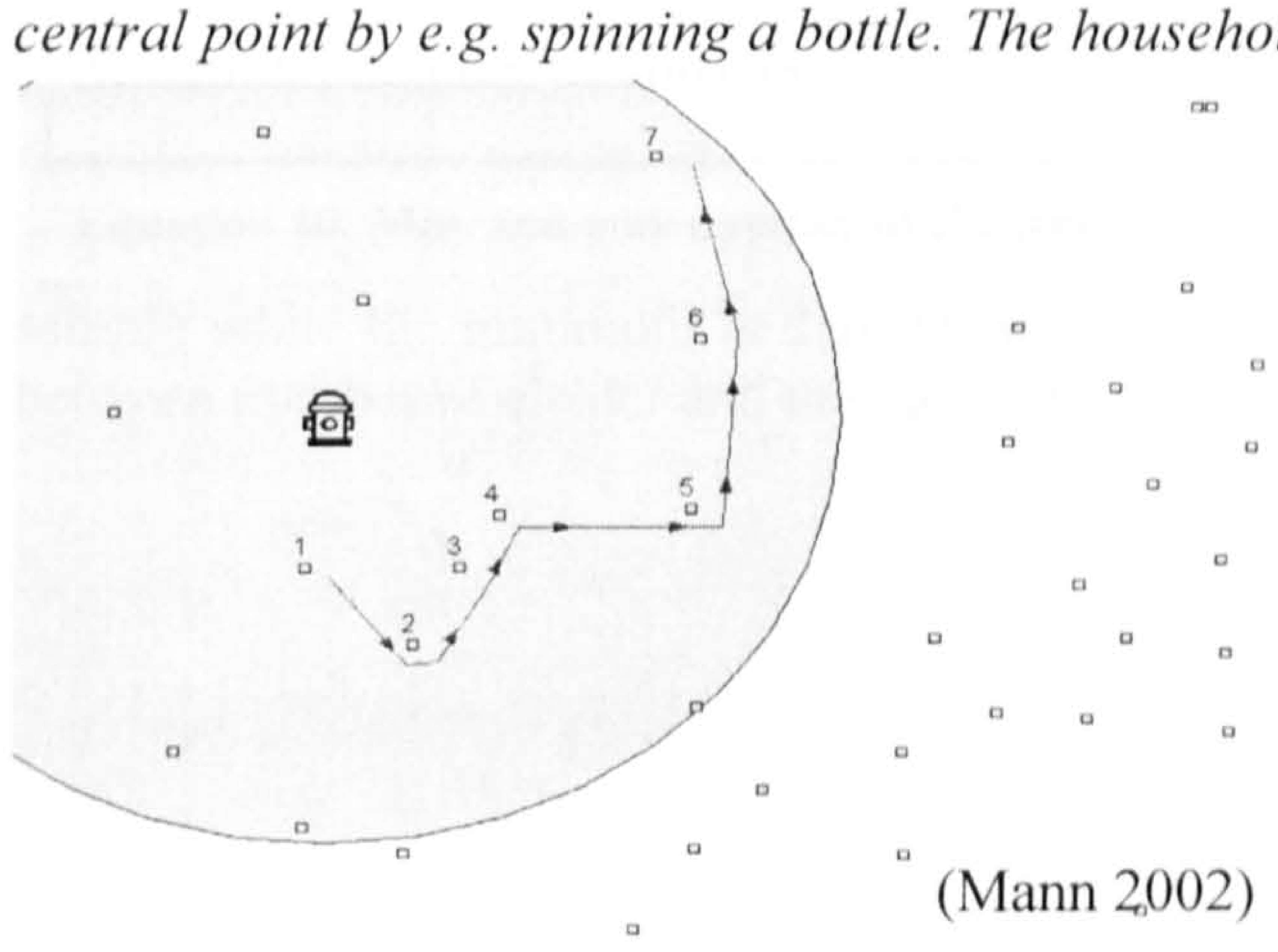


Figure 13: Geographical determinant to 'access to water'.

To determine how typical this is, more data sets will be analyzed in the future of the project. To have a better idea of the size of design effect and rate of homogeneity and how it relates with other cross sectional survey data, some other studies where consulted of which one (Qaba 1999) is added in for comparison.

$$\bar{\rho} = \frac{\overline{Deff} - 1}{\bar{b} - 1} = \frac{7.5 - 1}{22 - 1} = 0.3095 \cong 0.31$$

Deff. design effect
ρ rate of homogeneity *roh*
b take or cluster sample size

Sampling with a sample frame

For the testing of the WASH survey, only sampling with a sample frame will be used. As two-stage sampling is used not only is there a need to calculate the required sample size but also the number of clusters has to be determined. Equation 9 allows the calculation of the number of cluster needed when p, d, b and deff are known.

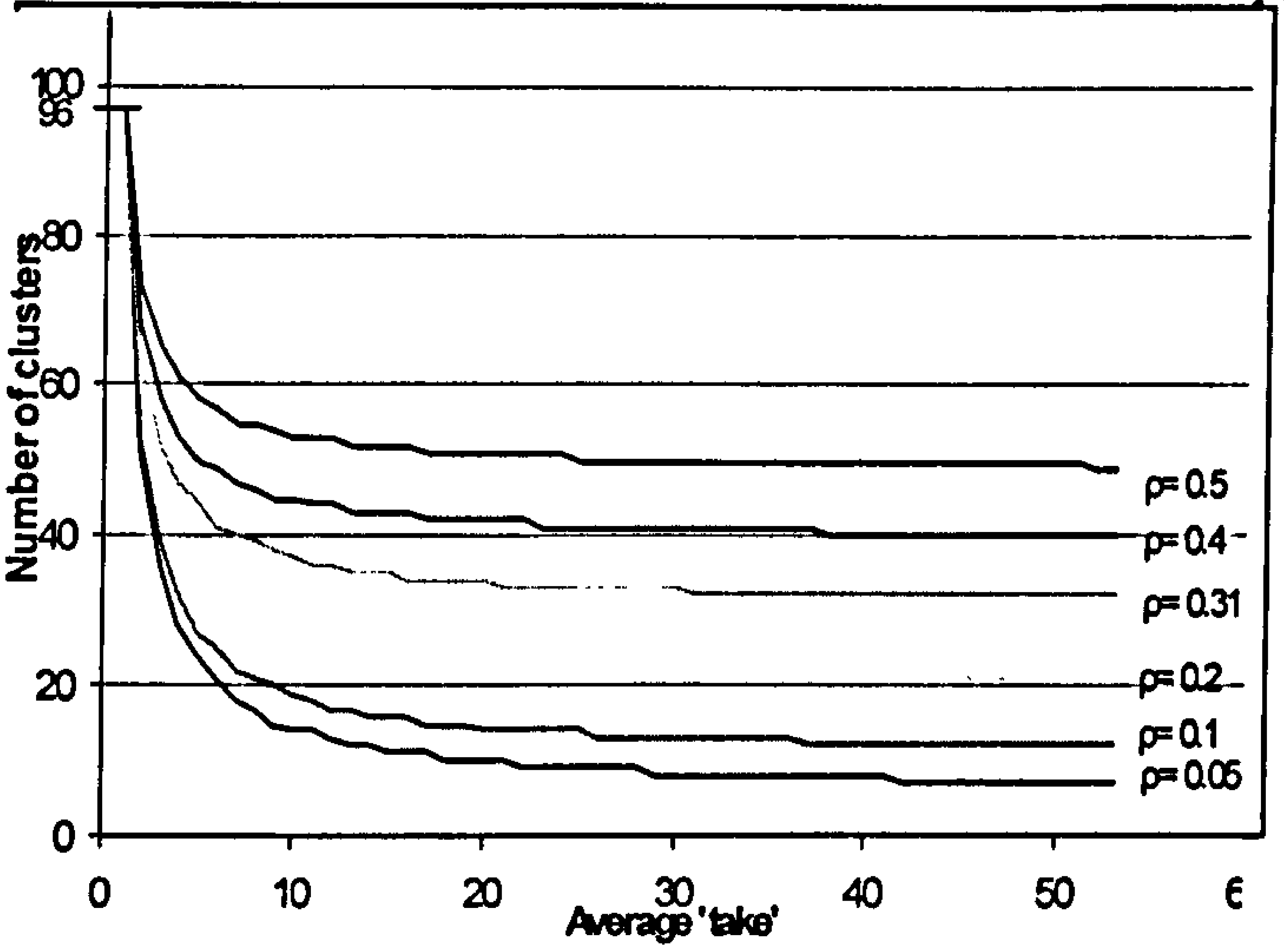


Figure 14: Number of clusters versus average 'take' size to achieve equivalent precision?

We can calculate *s* for 10% points confidents interval at the 95% confidence level (z=1.96) as shown. Using the worst case value of 50% as expected proportion and replacing the deff in Equation 9 by Equation 7 which with the other values result in the shown equation. There is no optimal combination to be found on the basis of this equation as shown in Figure 14. To calculate the max and minimum number of clusters, the limits for this function are calculated for ρ = 3.1

$$\lim_{\bar{b}\to\infty} \frac{66 + 30\bar{b}}{\bar{b}} = 30$$

$$\lim_{\bar{b}\to 1} \frac{66 + 30\bar{b}}{\bar{b}} = 96$$

For any value of ρ the equation becomes as shown in Equation 10. The jagged curve is because only integers (sample) can be use in the equation with only limited valid cluster and take combinations.The maximum number of clusters is occurs when the take size is 1 which corresponds with a simple random sample while the minimum is dependent on ρ. There is however no optimal relation between number of cluster and the take size.

Minimum number of clusters	$\lim_{\bar{b}\to\infty} \frac{96(1-\rho) + 96 \cdot \rho \cdot \bar{b}}{\bar{b}} = 96\rho$
Maximum number of clusters	$\lim_{\bar{b}\to 1} \frac{96(1-\rho) + 96 \cdot \rho \cdot \bar{b}}{\bar{b}} = 96$

Equation 10: Min. and max number of clusters

Cost factor in the cluster-take relation

One of the main factors for cluster sampling is the cost factor. Introducing this cost factor into the equation as shown in Figure 15 shows that an optimum can be reached. To only include one extra variable on cost in the equation cost ratio between the 'extra' cluster cost and the 'cost of sampling one BSU' was used. The cluster cost is the extra cost a cluster adds to the survey budget on top of the cost of sampling all the BSUs in that cluster. The (cluster cost)/(cost of sampling one BSU) ratio including an example is explained below. The graph in Figure 15 is not smooth because only integers where used in the formulas. The graph also shows clearly that the optimal sample size can change significantly with slight variations of ρ. To get a better understanding of the cost and its relation with the sample size the cost ratio between cluster and sample size are plotted in Figure 16. It is clear that between sample size of 25 and 1250 the cost of the survey is roughly the same. This area can be identified in Figure 16 to show the various suitable combinations.

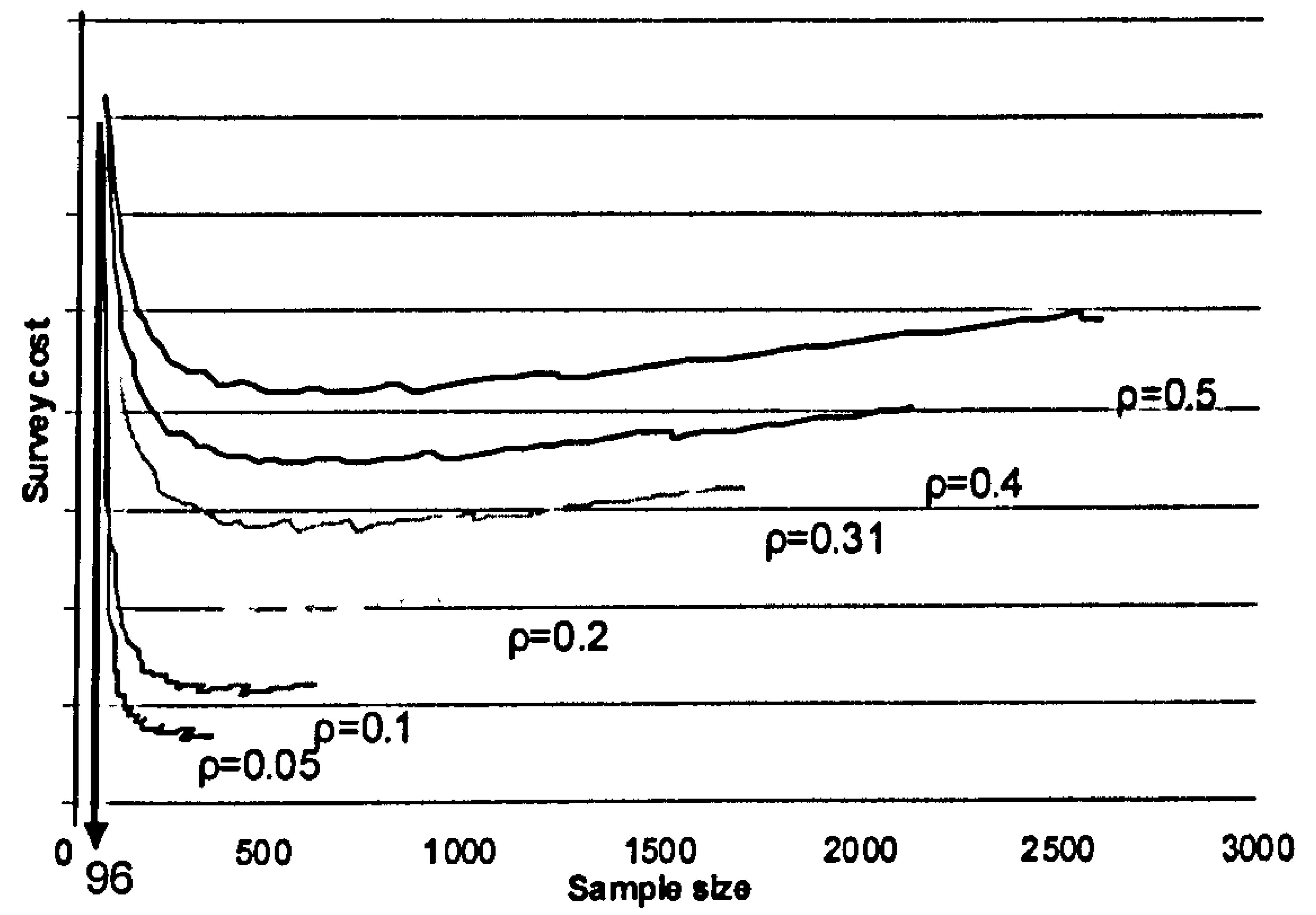


Figure 15: Optimal cost versus sample size

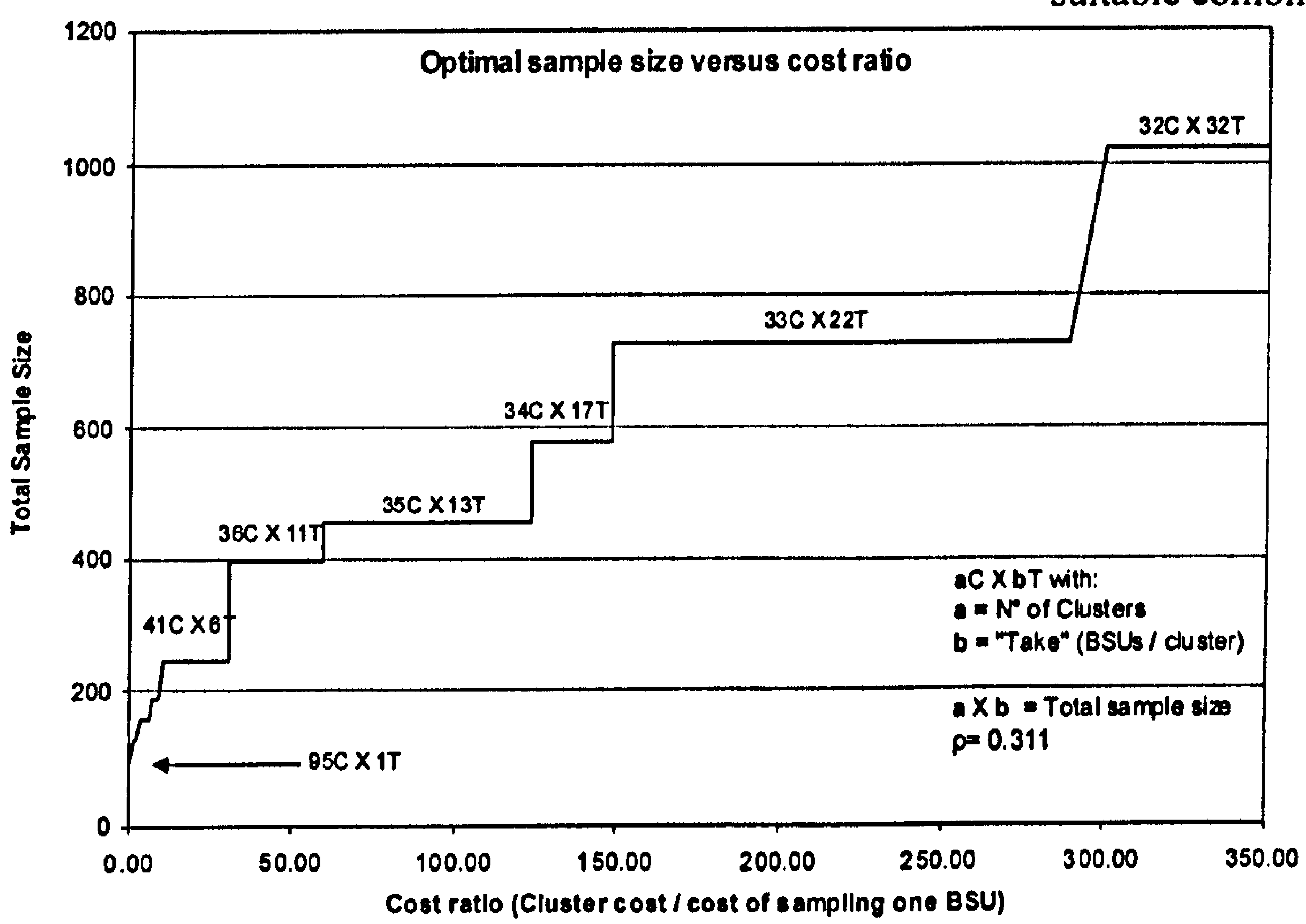


Figure 16: Optimum sample size versus cost ratio

The formulas used are based on sampling 'with replacement'. They can only approximate 'sampling without replacement' when the cluster population sizes are much larger that the take. In practices this condition is fulfilled when the cluster population is at least 10 times larger than the take.

Where the lines in the graph are vertically there are two optimal combinations. At a cost ratio of 148 the combinations 34C X 17T and 33C X 22T will give the same overall cost for two distinctive different sample sizes. Cost In the calculations is normalized at the cost of surveying a single sample. It shows that despite the cost expressed in cost per unit sampled, the two different sample sizes are significantly different.

Survey cost (in samples) = sample size + cost of cluster (in samples)

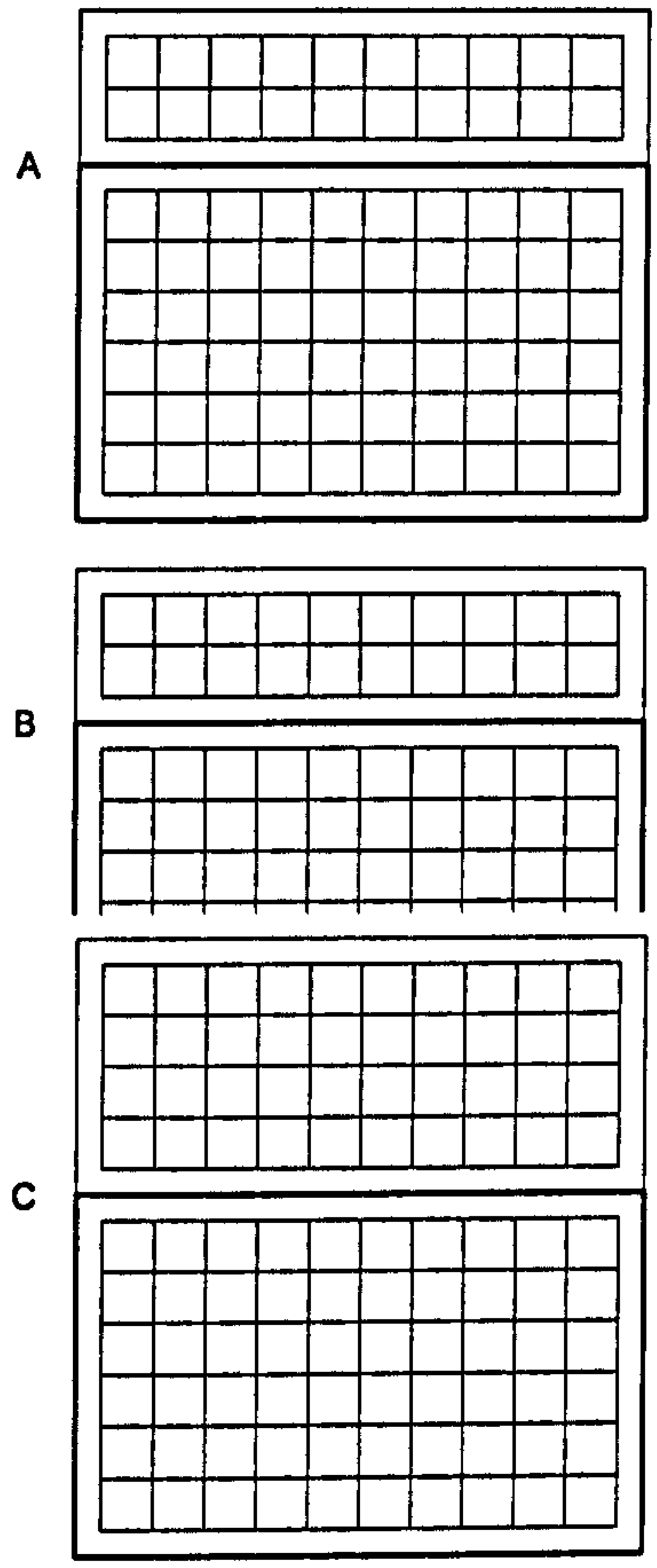
$$\text{sample size} = 34C \times 17T = 578 \quad \Rightarrow \quad 578 + 34C(148) = 5610 \text{ (cost in nr. of samples)}$$

$$\text{sample size} = 33C \times 22T = 726 \quad \Rightarrow \quad 726 + 33C(148) = 5610 \text{ (cost in nr. of samples)}$$

Any cluster/sample cost ratio over 350 results in the same outcome of 32 clusters of 32 BSUs each.

Cluster/Sample cost ratio

In a cluster sampling survey two different costs identified, the cost of each sample and the extra cost for each cluster as illustrated in Figure 17. The cost of sampling 1 BSU would be typically the salary and stationary cost for one sample while the extra cluster cost would be lodging transport, salary and other cost during hours that no surveying is done such as while traveling to a PSU. For example imagine cluster A in Figure 17 which is one of 30 clusters in a given survey. The take is 20 BSU and the extra cluster cost is equivalent to cost of 60 sampled BSUs. This results in a cost ratio of 60/1=60 and a total cluster cost of sampling (30 cluster x 20 BSU) + (30 x 60 Cluster/Sample ratio) = <u>2400 BSUs</u>. If we want to double the sample size two possible ways of doing that is to double the number of clusters from 30 to 60 as shown in Figure 17B and keep the same cost per cluster.



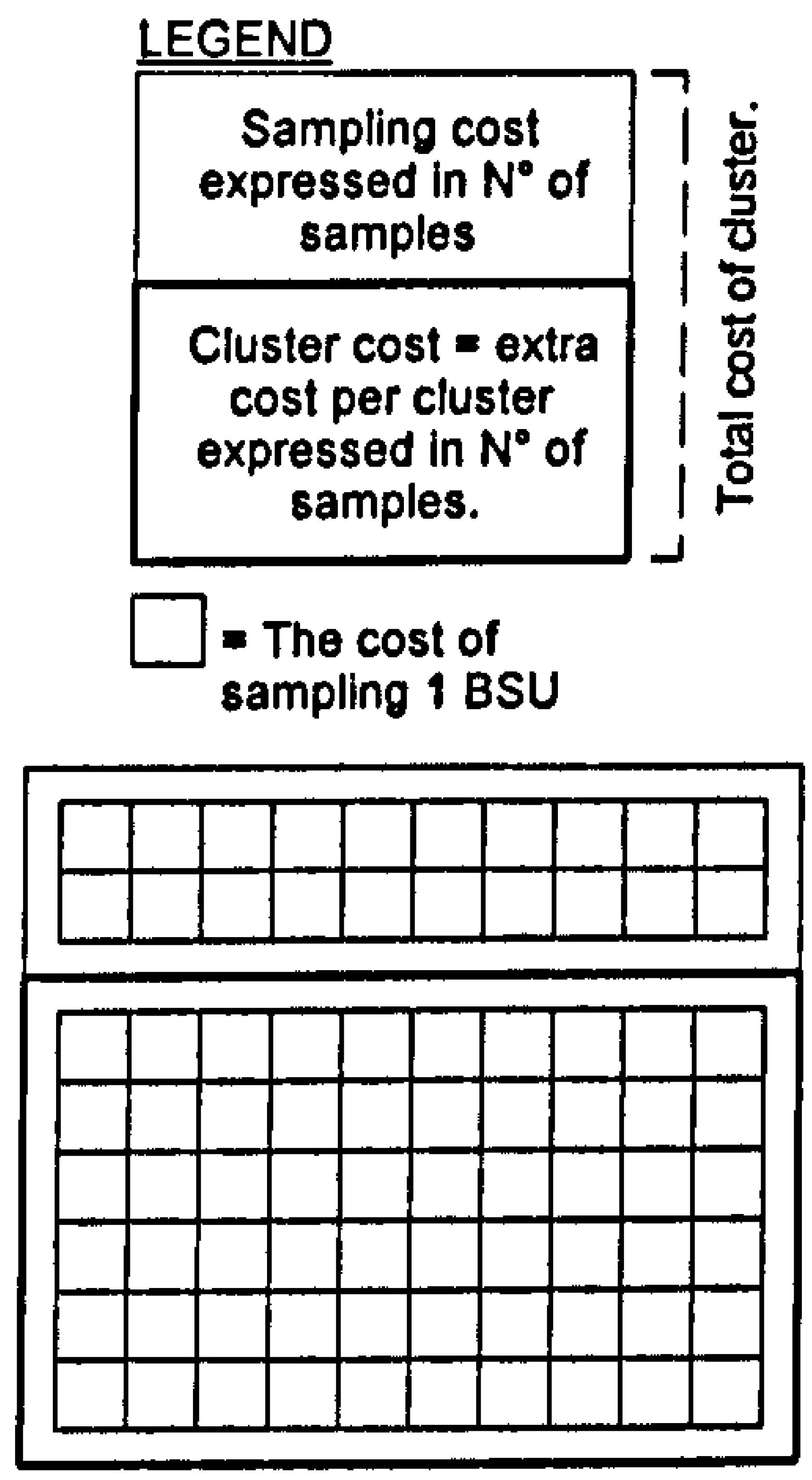


Figure 17: Cluster/Sample cost ratio

The survey would than cost the equivalent of sampling (60 cluster x 20 BSU) + (60 clusters x 60 Cluster/Sample ratio) = <u>4800 BSUs</u>. Another way of doubling the sample size is doubling the take in each cluster and keeping the same number of clusters as shown in Figure 17C. The cost of the survey would than cost only the equivalent of sampling (30 cluster x 40 BSU) + (30 clusters X 60 Cluster/Sample ratio) = <u>3000 BSUs.</u>

Appendix B Existing water and sanitation data in Laos and Thakhek District

The following is a non exhaustive list of other water sanitation and hygiene practice data in Laos as base of comparison to the results obtained in the Vision 21, WASH survey in Thakhek district August 2003.

MICS II, JMP, WHO

On www.childinfo.org the following information could be found in PDF format. This information was collected by the Joint Monitoring Program (JMP) of UNICEF and WHO for the 2000 water and sanitation global assessment.

			DRINKING WATER				SANITATION			
			URBAN		RURAL		URBAN		RURAL	
Source	Code	Year	data used for estimates	other data	data used for estimates	other data	data used for estimates	other data	data used for estimates	other data
The International Drinking Water Supply and Sanitation Decade. Review of National Progress (as at December 1983). WHO 1986.	WHO83	1983		28		20		13		4
The International Drinking Water Supply and Sanitation Decade. Review of National Progress (as at December 1988). WHO 1990.	WHO88	1988		61		17				6
The International Drinking Water Supply and Sanitation Decade. End of Decade Review (as at December 1990). WHO1992.	WHO90	1990		47		25		30		8
Water Supply and Sanitation Sector Monitoring Report 1993 (Sector Status as of 31 December 1991)	JMP93	1991		54		54		97		8
Water Supply and Sanitation Sector Monitoring Report - 1996. Sector Status as of 31 December 1994. WHO/UNICEF 1996.	JMP96	1994		40		39		70		13
Global Water Supply and Sanitation Assessment 2000. Water Supply and Sanitation Sector Questionnaire - 1999. (Form 6 sent to WHO)	JMP99	1999		59		100		84		34
Multiple Indicator Cluster Survey, Laos, 2000	MICS00	2000	61		29		67		19	
Estimates		1995	61		29		67		19	
		2000	61		29		67		19	

Table 13: Access to improved water drinking sources and improved sanitation in Lao PDR by JMP.

MICS		1996
INSUFFICIENT DATA		
SANITATION	Urban	Rural
TOTAL		
Access to Improved sanitation		

Source: Multiple Indicator Cluster Survey, Laos, 1996.

MICS		2000
SANITATION	Urban	Rural
Flush to sewage system or septic tank	2.6	0.1
Por flush latrine (water seal type)	54.8	10.2
Traditional pit latrine	9.7	8.6
Other	0	0.1
Missing	1.9	2.3
No facilities/bush/field	31	78.7
TOTAL	100	100
Access to Improved sanitation	67%	19%

Source: Multiple Indicator Cluster Survey, Laos, 2000.

FORM6/WHO		1999
(Population in thousands)		
SANITATION	Urban	Rural
Population served with household connections to conventional sewers	0	0
Population without household connections but served with adequate, private or shared on-site system	676	1321.58
Total population served	676	1321.58
Total population unserved	131.8	2588.42
Total population	807.8	3910
Access to Improved sanitation	84%	34%

Source: Global Water Supply and Sanitation Assessment 2000. Water Supply and Sanitation Sector Questionnaire - 1999. (Form 6 sent to WHO)

Table 14: Disaggregated information on sanitation for Lao PDR by the UNICEF/WHO, JMP.

Definition used for access are mentioned in the report.

Based on the population figures in Table 14 and the water and sanitation information in Table 13, we can calculate that according to the MICS survey the total estimated access to **improved drinking water sources** in Lao is **34%**. For **access to improved**

sanitation the results from **MICS** in Table 14 result in **27%** of the Lao having access to improved sanitation while the figures from WHO in the same table give **30%.** No confidence intervals are mentioned for these figures.

Lao National Statistical Centre

In its 'Statistical Yearbook 2002' the Lao National Statistical Centre only mentions water and sanitation statistics in Table 74, pages 103-4 which states details on the 'Millennium Development Goals' (Lao National Statistical Centre 2002).
The table below is a compilation of the data published by the National statistical office.

Area	Coverage (%)	
Urban	68	Source: UNICEF MISC II, Lao National Statistical Centre (NSC), Central Planning Committee (CPC), National Institute of Public Health (NIPH), Ministry of Health (MoH)
Rural	19	
Total	38	

Table 15: Proportion of people in 2000 with access to improved sanitation in Lao PDR

Area	Coverage (%)	
Urban	75	Source: UNICEF MISC II, Lao National Statistical Centre (NSC), Central Planning Committee (CPC), National Institute of Public Health (NIPH), Ministry of Health (MoH)
Rural	38	
Total	52	

Table 16: Proportion of people in 2000 with sustainable access to improved water source in Lao PDR.

MoH and Nam Saat

In its 'National Support Work Plan' (Lao MoH 2000), Nam Saat mentions measured, projected and planned national coverage's as mentioned in the table below. Although it is not clearly stated it is assumed that the coverage for the year 2000 is a projection rather than a measurement.

Area	Year 1999 (%)	Year 2000 (%)	Year 2005 (%)
Water Supply	54	75	67
Sanitation	34	38	47
School Latrines	4	52	21

Table 17: Nam Saat's Planned & projected proportion of people having access to water & sanitation.

Relevant information for the Vision 21 field survey, tables 25 to 28 from the 'Report on the National Health Survey' (Lao MoH 2001) are adapted and reproduced below in tables Table 18 to Table 21. In the tables below we have highlighted the central region as it holds Thakhek district.

(n=6449)	Main source of water												
	Safe Water									Unsafe Water			**Households using save drinking**
	Piped												
	into dwelling	into yard or plot	Public tap	Tube well/ borehole	Protected dug well	Bottled water	Tanker truck vendor	Rain water collection	GFS	Unprotected dug well	River, pond or streaam	others	
Region													
North	5.4	6.3	5.6	3.2	8.5	0.3	0.0	0.1	13.6	12.0	43.8	1.2	**43.0**
Central	8.6	0.9	1.4	13.5	16.0	8.4	0.1	0.1	5.3	25.4	12.2	8.0	**54.3**
South	5.5	11.1	3.3	34.3	1.8	0.5	0.2	0.0	2.1	8.6	12.6	19.7	**58.7**
Area (National)													
Urban	17.4	9.3	4.1	17.0	13.3	9.1	0.1	0.2	5.2	16.1	5.0	3.3	**75.5**
Rural	0.2	3.1	2.7	15.7	7.4	0.3	0.1	0.0	8.1	16.7	32.7	12.8	**37.6**
Total	**6.8**	**5.5**	**3.2**	**16.2**	**9.7**	**3.7**	**0.1**	**0.1**	**7.0**	**16.5**	**22.2**	**9.2**	**52.0**

Table 18: Percentage of households by use of water source per area and region in 2000.

(n=4519)		Time (minutes)		
		<5	5-10	>10
Region				
	North	26.1	53.8	20.2
	Central	9.3	40.3	50.3
	South	14.2	5.1	34.7
National		**16.6**	**48.4**	**35.0**

Table 19: Time spend for getting water by region in 2000.

(n=6449)	Types of latrine					
	Flush to sewer system /septic tank	Pour flush	Improved pit	Other	Not interviewed	**Households using latrines**
Region						
North	0.3	30.8	13.7	0.2	0	**45.0**
Central	1.9	32.1	10.0	0	0	**43.9**
South	0.6	16.0	2.5	0.1	7.7	**19.2**
Area (National)						
Urban	2.6	54.8	9.7	0	1.9	**67.1**
Rural	0.1	10.2	8.6	0.1	2.3	**19.0**
Total	**1.0**	**27.2**	**9.0**	**0.1**	**2.2**	**37.7**

Table 20: Percentage of latrines used in 2000 by type of latrine, areas and regions.

(n=3061)	Excreta disposal method for children < 3 years				
	Thrown in the toilet	Thrown outside the yard	Buried in the yard	Not disposed	Other
Region					
North	9.6	16.1	21.4	51.1	1.8
Central	16.2	11.3	26.4	44.1	2.0
South	10.0	10.9	21.5	45.4	12.3
Area (National)					
Urban	35.8	4.8	30.4	23.0	7.0
Rural	4.3	15.1	20.7	54.1	5.8
Total	**12.0**	**12.6**	**23.2**	**46.7**	**5.5**

Table 21: Method of excreta disposal for children under 3 years old in 2000.

The following figures where collected from NAM SAAT's 'End of Year Report' for the 2001-2002 (Nam Saat 2002).

	Total	Use clean water		Use toilet	
	Pop.	Pop.	%	Pop.	%
Province					
Khammouan	310361	174265	56%	85299	27%
District					
Thakhek	75723	56225	74%	39390	52%

Thakhek District Statistical office.

Data collected systematically by the Thakhek Statistical Office (on 25-26 July 2003) from the village heads in the district we compiled the following information. The figures in *italics* are calculated from the information given by the statistical office.

Area	Number of people	Number of families	Families having clean water	
			number	%
Urban	34930	6400	5492	*86*
Rural	*44368*	*8222*	*3543*	*43*
District	79298	14622	9035	*62*

Table 22: Information on access to clean water in 2003 for Thakhek district.

In all the data found above there were no confidence given. With the exception of UNICEFs MICS no definitions were given for any of the reported data.

Appendix C Interview form in Lao

Vision 21 Field Trials. Lao PDR, August 2003 — Final Lao Version H 01

Vision 21 Household Information Sheet (ຂໍ້ມູນຂອງຄົວເຮືອນ)

SR	Survey reference: V 2 1 L A O	CI	Cluster ID / / /	HHN	Household N° H 3422
PR	Province K H A M M U A N	VA	yes 1 / No 3		

DI — District

Tha Khaek	02	Not used	12	Not used	24	Not used	34
Not used	10	Not used	22	Not used	32	Not used	46

VL — Village

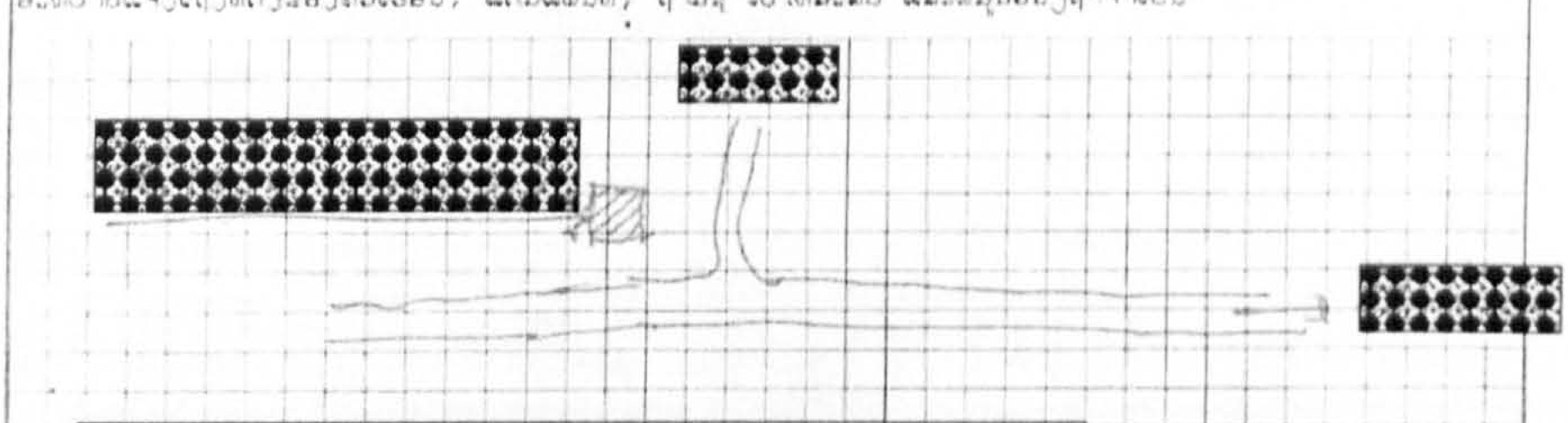
ຈອມແຈ້ງ	01	ດົງມ່ວງໄຂ່	17	ຖ້ຳ	35	ໂພນສະອາດ	55
ຈອມເພັດ	03	ປາກເປັງ	19	ທ່າແຂກກາງ	37	ໂພນເຍຍບັດຍ	57
ຈອມທອງ	05	ດອນເຮືອນຊ້າງ	21	ທ່າແຂກເໜືອ	39	ສ້ານະລາດ	59
ສຸກສະຫວັນ	07	ດອນໂດນ	23	ທ່າເດື່ອ	41	ເວີນ	61
ສີບສະໝຸກ	09	ດອນໃຫຍ່	25	ນາໄກ່ເຂ່ຍ	43	ວຽງວິໄລ	63
ນາບົງ	11	ໃໝ່ໂພສີ	27	ນາໂດນ	45	ທາດຄຳ	65
ດອນມ່ວງ	13	ຕານ	29	ປັງເຊງ	47	ໜອງບົວທອງ	67
ດົງກົມມະເກດ	15	ໃໝ່ທ່າເດທອງ	33	ໂພນສະໜາມ	49	ໜອງຊີ	69

HU ໜ່ວຍທີ [redacted] HN ເຮືອນເລກທີ [redacted] ຂໍ້ມູນຈາກປ້າຍເຮືອນ

RN ກີ່ຈັກຄົວເຮືອນອາໄສຢູ່ນີ້ 0 1

NH ຊື່ຄົວເຮືອນທີ່ຖືກສຳພາດ [redacted]

ອະທິບາຍແຈ້ງເຖິງທີ່ຕັ້ງຂອງຄົວເຮືອນ; ແຕ້ມແຜນທີ່, ຖາມຊື່ ເບີໂທລະສັບ ແລະຂໍ້ມູນອື່ນໆທີ່ຈຳເປັນ



[redacted] For privacy protection

second visit → first visit

SV	Survey visits	1 2 3 4 5	SS	Survey status	Done 1	Non response 3	No BSU 5
VV	Validation visits	1 2 3 4 5	VS	Validat. status	Done 1	Non response 3	No BSU 5

ການອ່ານຄ່າຕ່າງໆຈາກ GPS

1. ກົດ Mark
2. ຈົດເອົາຄ່າຕ່າງໆ: ລະຫັດຈຸດໝາຍ Waypoint, ຕຳແໜ່ງເສັ້ນຂະໜານ LA ແລະ ຕຳແໜ່ງເສັ້ນແວງ LO

GPS	ເບີເຄື່ອງ GPS	06	LA	ເສັ້ນຂະໜານ (N+/S-)	+017.563 [redacted]
EPE	. m/f		LO	ເສັ້ນແວງ (E+/W-)	+104.671
WP	ລະຫັດຈຸດໝາຍ (Waypoint)	076///	CF	Coordinates Format	hddd.ddddd
MD	Map Datum	WGS48			

3. ກົດ Enter ເພື່ອບັນທຶກຂໍ້ມູນເຂົ້າ GPS

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DC	ວັນທີເກັບຂໍ້ມູນ	1 9 0 8 0 3	
S1	ລະຫັດຜູ້ເກັບຂໍ້ມູນທີ1	0 6	
S2	ລະຫັດຜູ້ເກັບຂໍ້ມູນທີ2		

DT	ປະເພດຂອງຂໍ້ມູນທີ່ເກັບ	
	ສຳພາດ (ໃຊ້ແບບຟອມສຳພາດ)	1
	ສັງເກດ (ໃຊ້ແບບຟອມສັງເກດ)	3

VAC	ໄດ້ເຮັດການເກັບກຳຂໍ້ມູນບໍ່?	
	ໄດ້ເຮັດ	5
	ບໍ່ໄດ້ເຮັດ	7

ຖ້າ ບໍ່ໄດ້ເຮັດ ໃຫ້ບອກເຫດຜົນ: [illegible]

ຂໍ້ແນະນຳໃນການກັບມາເກັບຂໍ້ມູນອີກ

ຖ້າ ໄດ້ເຮັດ ໃຫ້ໃສ່ລະຫັດແບບຟອມທີ່ໃຊ້ ! ! !

DC	ວັນທີເກັບຂໍ້ມູນ	2 5 0 8 0 3	
S1	ລະຫັດຜູ້ເກັບຂໍ້ມູນທີ1		
S2	ລະຫັດຜູ້ເກັບຂໍ້ມູນທີ2	0 5	

DT	ປະເພດຂອງຂໍ້ມູນທີ່ເກັບ	
	ສຳພາດ (ໃຊ້ແບບຟອມສຳພາດ)	1
	ສັງເກດ (ໃຊ້ແບບຟອມສັງເກດ)	3

VAC	ໄດ້ເຮັດການເກັບກຳຂໍ້ມູນບໍ່?	
	ໄດ້ເຮັດ	5
	ບໍ່ໄດ້ເຮັດ	7

ຖ້າ ບໍ່ໄດ້ເຮັດ ໃຫ້ບອກເຫດຜົນ:

ຂໍ້ແນະນຳໃນການກັບມາເກັບຂໍ້ມູນອີກ

ຖ້າ ໄດ້ເຮັດ ໃຫ້ໃສ່ລະຫັດແບບຟອມທີ່ໃຊ້ ! ! !

5	0	9	4	9

DC	ວັນທີເກັບຂໍ້ມູນ	0 3	
S1	ລະຫັດຜູ້ເກັບຂໍ້ມູນທີ1		
S2	ລະຫັດຜູ້ເກັບຂໍ້ມູນທີ2		

DT	ປະເພດຂອງຂໍ້ມູນທີ່ເກັບ	
	ສຳພາດ (ໃຊ້ແບບຟອມສຳພາດ)	1
	ສັງເກດ (ໃຊ້ແບບຟອມສັງເກດ)	3

VAC	ໄດ້ເຮັດການເກັບກຳຂໍ້ມູນບໍ່?	
	ໄດ້ເຮັດ	5
	ບໍ່ໄດ້ເຮັດ	7

ຖ້າ ບໍ່ໄດ້ເຮັດ ໃຫ້ບອກເຫດຜົນ:

ຂໍ້ແນະນຳໃນການກັບມາເກັບຂໍ້ມູນອີກ

ຖ້າ ໄດ້ເຮັດ ໃຫ້ໃສ່ລະຫັດແບບຟອມທີ່ໃຊ້ ! ! !

ຖ້າຟອມເພີ່ມເຕີມຖືກໃຊ້ໃຫ້ໝາຍໃສ່ນີ້ =>

Vision 21 Survey Questionnaire Sheet (ແບບຟອມສຳພາດ)

GI	ເພດຂອງຜູ້ໃຫ້ສຳພາດ		MI	ວຸດທິພາວະຂອງຜູ້ໃຫ້ສຳພາດ		HF	Household form N°	S 0949
ຊາຍ		1	ຜູ້ໃຫຍ່ (ອາຍຸ18 ປີຂຶ້ນໄປ)		5			
ຍິງ		3	ເດັກນ້ອຍ		7			

ST	ເວລາເລີ່ມການສຳພາດ	08 : 45	(Use 24H notation e.g. 5 am = 05:00, 5pm = 17:00)

S11 ມື້ວານນີ້ທ່ານເອົານ້ຳດື່ມມາຈາກແຫຼ່ງໃດສຳລັບຄົວເຮືອນຂອງທ່ານ?

Coding categories		Coding categories	
ນ້ຳປະປາ		ນ້ຳໜ້າດິນ	
ນ້ຳປະປາໃນເຮືອນ	11	ແມ່ນ້ຳ/ຫ້ວຍ	42
ນ້ຳປະປາພາຍໃນເດີ່ນບ້ານ/ຕອນດິນ	12	ໜອງ/ບຶງ/ແຫຼ່ງນ້ຳຜືນຂະໜາດໃຫຍ່	43
ນ້ຳປະປາສາທາລະນະ	13	ເຂື່ອນ	44
ຕໍ່ທໍ່ຈາກບ່ອນອື່ນທີ່ບໍ່ຖືກຕ້ອງ	14	ບໍ່ນ້ຳທີ່ຖືກປ້ອງກັນ	41
ນ້ຳສ້າງເປີດ		ບໍ່ນ້ຳທີ່ບໍ່ຖືກປ້ອງກັນ	45
ນ້ຳສ້າງເປີດໃນເຮືອນ	21	ໂຕ່ງນ້ຳຝົນຈາກຫຼັງຄາ	51
ນ້ຳສ້າງເປີດພາຍໃນເດີ່ນບ້ານ/ຕອນດິນ	22	ລົດຂາຍນ້ຳ/ນາຍຂາຍຕາມແຕ່ລະເຮືອນ	61
ນ້ຳສ້າງເປີດສາທາລະນະ	23	ນ້ຳ ກະຕຸກ/ນ້ຳດື່ມບໍລິສຸດ	71
ນ້ຳສ້າງປິດ ຫຼື ນ້ຳບາດານ		ອື່ນໆ	96
ນ້ຳສ້າງປິດ/ບາດານ ໃນເຮືອນ	31	(ໃຫ້ລະບຸ)	
ນ້ຳສ້າງປິດ/ບາດານ ພາຍໃນເດີ່ນບ້ານ/ຕອນດິນ	32	(ຖ້າແຫຼ່ງນ້ຳເປັນແຫຼ່ງນ້ຳໜອງ ເຂື່ອນບ້ານໃດ້ ໝາຍໃສ່	
ນ້ຳສ້າງປິດ/ບາດານ ສາທາລະນະ	33	ວ່າ ພາຍໃນເດີ່ນບ້ານ/ຕອນດິນ)	

S12 ມື້ວານນີ້ (ເທື່ອຫຼ້າສຸດ) ທ່ານໃຊ້ເວລາເທົ່າໃດເພື່ອໄປຫາແຫຼ່ງນ້ຳດື່ມດັ່ງກ່າວ, ເອົານ້ຳ ແລະກັບຄືນມາຮອດ ເຮືອນ?

Coding categories		Go To	Remarks
ຊົ່ວໂມງ; ນາທີ (ລວມທັງເວລາທີ່ຖ້າເອົານ້ຳ)	00 h 15 m		
ມີນ້ຳຢູ່ເຮືອນ (ບໍ່ໄດ້ໄປເອົານ້ຳຫຼືມີຄົນເອົາມາສົ່ງຮອດເຮືອນ)	00		

S13 ພາຍໃນ 7 ວັນທີ່ຜ່ານມາ ມີຈັກມື້ທີ່ທ່ານບໍ່ສາມາດເອົານ້ຳດື່ມຈາກແຫຼ່ງນ້ຳດັ່ງກ່າວ?

Coding categories		Go To	Remarks
ຈຳນວນມື້ທີ່ບໍ່ສາມາດເອົານ້ຳຈາກແຫຼ່ງດັ່ງກ່າວ			
ສາມາດເອົານ້ຳດື່ມຈາກແຫຼ່ງນ້ຳດັ່ງກ່າວໄດ້ທຸກມື້	0	S14	=> 0: ຂ້າມໄປຕອບຂໍ້ S14 ເລີຍ

S13b ພາຍໃນ 7 ວັນທີ່ຜ່ານມາຖ້າມີບາງມື້ທີ່ທ່ານບໍ່ສາມາດເອົານ້ຳດື່ມໄດ້, ຍ້ອນຫຍັງ?

Coding categories	Yes	No	Coding categories	Yes	no
ບໍ່ມີເງິນຈ່າຍ	1	3	ບໍ່ສະບາຍ (ສຸຂະພາບບໍ່ສົມບູນ)	1	3
ບໍ່ມີເວລາໄປເອົາ	5	7	ບໍ່ຕ້ອງການເພາະມີພຽງພໍແລ້ວ	5	7
ແຮງດັນນ້ຳບໍ່ພໍ	9	2	ອື່ນໆ	9	2
ມີຄົນຖ້າຄືຫຼາຍໂພດ	4	6	(ໃຫ້ລະບຸ)		

S14 ແຫຼ່ງນ້ຳດື່ມດັ່ງກ່າວນີ້ສາມາດຊົມໃຊ້ໄດ້ຕະຫຼອດປີບໍ່?

Coding categories		Go To	Remarks
ໄດ້, ໃຊ້ໄດ້ຕະຫຼອດປີ	1	S16	=> 1: ຂ້າມໄປຕອບຂໍ້ S16 ເລີຍ
ບໍ່ໄດ້, ບໍ່ສາມາດໃຊ້ໄດ້ຕະຫຼອດປີ	3		

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S15	ມີເດືອນໃດແດ່ທີ່ແຫຼ່ງນ້ຳດື່ມດັ່ງກ່າວບໍ່ສາມາດໃຊ້ໄດ້?							
Coding categories	ໃຊ້ໄດ້	ບໍ່ໄດ້	Coding categories	ໃຊ້ໄດ້	ບໍ່ໄດ້	Coding categories	ໃຊ້ໄດ້	ບໍ່ໄດ້
ມັງກອນ	1	3	ພຶດສະພາ	1	3	ກັນຍາ	1	3
ກຸມພາ	5	7	ມິຖຸນາ	5	7	ຕຸລາ	5	7
ມີນາ	9	2	ກໍລະກົດ	9	2	ພະຈິກ	9	2
ເມສາ	4	6	ສິງຫາ	4	6	ທັນວາ	4	6
Mark Not to ALL the months this source is not available)								

S16	ທ່ານມີການບຳບັດນ້ຳດື່ມທີ່ໄປຕັກມານັ້ນຢູ່ບໍ່ກ່ອນທີ່ຈະດື່ມ? (ຖາມບຳບັດເມື່ອໃຊ້ໃນລະດູເດືອນເທົ່ານັ້ນ)		
Coding categories		Coding categories	
ບໍ່ມີການປຸງແຕ່ງເລີຍ/ດື່ມເລີຍ	11	ຂ້າເຊື້ອດ້ວຍ ກລໍ	21
ປະໃຫ້ມີການຕົກຕະກອນ	13	ເຮັດໃຫ້ຕົກຕະກອນດ້ວຍສານສົ້ມຫຼືສານເຄມີອື່ນໆ	23
ຕົ້ມ	15	ຂ້າເຊື້ອດ້ວຍ ແສງຕາເວັນ	25
ກອງດ້ວຍຜ້າ	17		
ກອງລະອຽດ (ດ້ວຍ Ceramic, ຊາຍ)	19	ອື່ນໆ	96
		(ລະບຸ)	

S21	ທ່ານໃຊ້ແຫຼ່ງນ້ຳອື່ນ (ສຳລັບທຳຄວາມສະອາດ) ນອກຈາກແຫຼ່ງນ້ຳດື່ມທີ່ກ່າວມາຂ້າງເທິງນີ້ບໍ່?		
Coding categories		Go To	Remarks
ແມ່ນແລ້ວ, ຂ້ອຍໃຊ້ແຫຼ່ງນ້ຳອື່ນອີກ	1		
ບໍ່, ຂ້ອຍໃຊ້ແຕ່ແຫຼ່ງນ້ຳດຽວເທົ່ານັ້ນ	3	S31	=> 3: ຂ້າມໄປຕອບຂໍ້ S31 ເລີຍ

S22	(ມື້ວານນີ້) ແຫຼ່ງນ້ຳໃຊ້ຕົ້ນຕໍ (ທີ່ບໍ່ແມ່ນນ້ຳດື່ມ) ຂອງຄົວເຮືອນທ່ານເອົາມາແຕ່ໃສ?		
Coding categories		Coding categories	
ນ້ຳປະປາ		ນ້ຳໜ້າດິນ	
ນ້ຳປະປາໃນເຮືອນ	11	ແມ່ນ້ຳ/ຫ້ວຍ	42
ນ້ຳປະປາພາຍໃນເດີ່ນບ້ານ/ຄອນດິນ	12	ໜອງ/ບຶງ/ແຫຼ່ງນ້ຳຝົນຂະໜາດໃຫຍ່	43
ນ້ຳປະປາສາທາລະນະ	13	ເຂື່ອນ	44
ຊື້ຈາກບ່ອນອື່ນທີ່ບໍ່ຖືກຕ້ອງ	14	ບໍ່ນ້ຳທີ່ຖືກປ້ອງກັນ	41
ນ້ຳສ້າງເປີດ		ບໍ່ນ້ຳທີ່ບໍ່ຖືກປ້ອງກັນ	45
ນ້ຳສ້າງເປີດໃນເຮືອນ	21	ໄຫ່ງນ້ຳຝົນຈາກຫຼັງຄາ	51
ນ້ຳສ້າງເປີດພາຍໃນເດີ່ນບ້ານ/ຄອນດິນ	22	ລົດຂາຍນ້ຳ/ນາຍຂາຍຕາມແຕ່ລະເຮືອນ	61
ນ້ຳສ້າງເປີດສາທາລະນະ	23	ນ້ຳ ກະຕຸກ	71
ນ້ຳສ້າງປິດ ຫຼື ນ້ຳບາດານ		ອື່ນໆ	96
ນ້ຳສ້າງປິດ/ບາດານ ໃນເຮືອນ	31	(ລະບຸ)	
ນ້ຳສ້າງປິດ/ບາດານ ພາຍໃນເດີ່ນບ້ານ/ຄອນດິນ	32	(ຖ້າແຫຼ່ງນ້ຳເປັນແຫຼ່ງນ້ຳຂອງ ເພື່ອນບ້ານໃຫ້ ໝາຍໃສ່	
ນ້ຳສ້າງປິດ/ບາດານ ສາທາລະນະ	33	ວ່າ ພາຍໃນເດີ່ນບ້ານ/ຄອນດິນ)	

S23	ມື້ວານນີ້ (ຫຼືຄັ້ງຫຼ້າສຸດ) ທ່ານໃຊ້ເວລາເທົ່າໃດເພື່ອໄປຫາແຫຼ່ງນ້ຳໃຊ້ດັ່ງກ່າວ, ເອົານ້ຳແລະກັບຄືນມາຮອດເຮືອນ?		
Coding categories		Go To	Remarks
ຊົ່ວໂມງ: ນາທີ (ລວມທັງເວລາເຂົ້າຄິວ)	__ h __ m		
ມີນ້ຳຢູ່ເຮືອນ (ບໍ່ໄດ້ໄປເອົານ້ຳ)	00		

S24	ພາຍໃນ 7 ວັນທີ່ຜ່ານມາ ມີຈັກມື້ທີ່ທ່ານບໍ່ສາມາດເອົານ້ຳໃຊ້ຈາກແຫຼ່ງນ້ຳດັ່ງກ່າວ?		
Coding categories		Go To	Remarks
ຈຳນວນມື້ທີ່ບໍ່ສາມາດເອົານ້ຳຈາກແຫຼ່ງດັ່ງກ່າວ			
ສາມາດເອົານ້ຳມາໃຊ້ໄດ້ທຸກມື້	0	S25	=> 0: ຂ້າມໄປຕອບຂໍ້ S25 ເລີຍ

S24b ພາຍໃນ 7 ວັນທີ່ຜ່ານມາຖ້າມີບາງວັນທີ່ທ່ານບໍ່ສາມາດເອົານ້ຳໃຊ້ໄດ້, ຍ້ອນຫຍັງ?

Coding categories	Yes	No	Coding categories	Yes	no
ບໍ່ມີເງິນຈ່າຍ	1	3	ບໍ່ສະບາຍ (ສຸຂະພາບບໍ່ດີພໍ)	1	3
ບໍ່ມີເວລາໄປເອົາ	5	7	ບໍ່ຕ້ອງການເພາະມີພຽງພໍແລ້ວ	5	7
ແຮງດັນນ້ຳບໍ່ພໍ	9	2	ອື່ນໆ	9	2
ມີລໍຖ້າຄິວຫລາຍໂພດ	4	6	(ໃຫ້ລະບຸ)		

S25 ແຫຼ່ງນ້ຳໃຊ້ດັ່ງກ່າວນີ້ສາມາດນຳໃຊ້ໄດ້ຕະຫຼອດປີບໍ່?

Coding categories		Go To	Remarks
ໄດ້, ໄດ້ຕະຫຼອດປີ	1		
ບໍ່ໄດ້, ບໍ່ສາມາດໃຊ້ໄດ້ຕະຫຼອດປີ	3		

S26 ມີເດືອນໃດແດ່ທີ່ແຫຼ່ງນ້ຳໃຊ້ດັ່ງກ່າວບໍ່ສາມາດໃຊ້ໄດ້?

Coding categories	ໃຊ້ໄດ້	ບໍ່ໄດ້	Coding categories	ໃຊ້ໄດ້	ບໍ່ໄດ້	Coding categories	ໃຊ້ໄດ້	ບໍ່ໄດ້
ມັງກອນ	1	3	ພຶດສະພາ	1	3	ກັນຍາ	1	3
ກຸມພາ	5	7	ມິຖຸນາ	5	7	ຕຸລາ	5	7
ມີນາ	9	2	ກໍລະກົດ	9	2	ພະຈິກ	9	2
ເມສາ	4	6	ສິງຫາ	4	6	ທັນວາ	4	6

Mark **No** to ALL the months this source is not available!

S31 ທ່ານຖ່າຍໜັກໃສ່ໃສ?

Coding categories		Go To	Remarks
ບໍ່ມີວິດຖ່າຍ/ຖ່າຍຕາມປ່າ/ທົ່ງນາ/ໃສ່ຖົງຢາງແລ້ວແກ່ອງຖິ້ມ	31		
ຝັງຫຼືຖົມ	32		
ຊຸ, ຫຼືຖ່າຍແລ້ວມີຄົນເອົາໄປຖິ້ມ/ເຮັດຝຸ່ນ	41		
ຂຸມວິດ/ຫ້ອງນ້ຳ			
ຂຸມວິດແບບເປີດ	21		ຂຸມທີ່ບໍ່ຖືກປິດຢ່າງມິດຊິດ
ຂຸມວິດແບບປິດ	22		ຂຸມທີ່ມີຝາປິດແລະມີປ່ອງທ້ອນ
ຂຸມວິດແບບມີລະບົບລະບາຍອາກາດ	23		ຂຸມແບບປິດທີ່ມີທໍ່ລະບາຍອາກາດ
ຫ້ອງນ້ຳຊັກໂຄກ			
ປ່ອຍໃຫ້ໄຫຼໄປຕາມລະບົບນ້ຳເສຍຫຼືຂຸມວິດຊຶມ	11		
ວິດແບບຖອກນ້ຳລ້າງ	12		
ວິດຍາວ	42		
ອື່ນໆ ____ (ໃຫ້ລະບຸ)	96		

S31b ທ່ານໃຊ້ເວລາດົນປານໃດຈາກເຮືອນຂອງທ່ານໄປຫາບ່ອນທີ່ທ່ານຖ່າຍ?

Coding categories		Go To	Remarks
ຈາກເຮືອນໄປຫາບ່ອນທີ່ທ່ານຖ່າຍໃຊ້ເວລາ (ຂາໄປເທົ່ານັ້ນ)	05 ນາທີ		(ຖ້າແມ່ນຫ້ອງນ້ຳລວມໃຫ້ນັບເວລາຖ້ານຳ)
ຫ້ອງນ້ຳຢູ່ໃນເຮືອນ	00		

S32 ທ່ານໃຊ້ວິດຖ່າຍຮ່ວມກັບໃຜ?

Coding categories		Go To	Remarks
ມີແຕ່ຄົນພາຍໃນຄອບຄົວ	1		
ໃຊ້ຮ່ວມກັບບາງຄົວເຮືອນ	3		
ຫ້ອງນ້ຳລວມທີ່ທຸກຄົນສາມາດໃຊ້ໄດ້	7		

S34	ທ່ານຕ້ອງໄດ້ຈ່າຍເງິນທຸກໆເທື່ອທີ່ໃຊ້ສ້ວມຖ່າຍບໍ່?		
Coding categories		Go To	Remarks
ຈ່າຍທຸກໆຄັ້ງທີ່ໃຊ້ຫ້ອງນ້ຳ	2		ຈ່າຍຕາມຄັ້ງທີ່ໄປ
ບໍ່ຈ່າຍທຸກຄັ້ງແຕ່ຈ່າຍເປັນເດືອນ	4		ຈ່າຍເປັນລາຍເດືອນຫຼືໄລຍະ
ບໍ່ໄດ້ຈ່າຍ / ໃຊ້ຟຣີ	6		ບໍ່ໄດ້ຈ່າຍຫຍັງເລີຍ

S35	ຄັ້ງຫຼັງສຸດທີ່ລູກຄົນນ້ອຍສຸດຂອງທ່ານຖ່າຍທ່ານມີຖິ້ມອາຈົມຂອງເຂົາ ດ້ວຍວິທີໃດ?		
Coding categories		Go To	Remarks
ບໍ່ໄດ້ມ້ຽນຫຼືປະໄວ້ຕາມບ່ອນທີ່ເຂົາຖ່າຍ	09		
ຖິ້ມອອກນອກເຮືອນ ແຕ່ຍັງຢູ່ໃນບໍລິເວນເດີ່ນບ້ານ	03		
ຖິ້ມອອກນອກຮົ້ວບ້ານ	04		
ຝັງຕາມບໍລິເວນເດີ່ນບ້ານ	05		
ຖິ້ມໃສ່ກອງຂີ້ເຫຍື້ອ, ທຸ່ມຫຼືຖັງຂີ້ເຫຍື້ອທີ່ບໍ່ມີຝາປິດ	11		ຈຸດການແຈ້ງກຳນົດຢູ່ໃນຂໍ້ນີ້
ຖິ້ມລົງຖັງຂີ້ເຫຍື້ອທີ່ມີຝາປິດແລະມີການເກັບເປັນປະຈຳ	12		ຖ້າບໍ່ມີການເກັບມ້ຽນເປັນປະຈຳຫຼືກໍ່ລະບົບໃຊ້
ລ້າງລົງຮ່າງຫຼືຮ່ອງ	06		ຈັດວາງຫຼືຝຶກຫັດໃຫ້ເດັກໆທີ່ອາດຖ່າຍທີ່ເຂົາເຈົ້າ
ເອົາຖ່າຍໃສ່ຫ້ອງນ້ຳເປັນປະຈຳ	01		ກຳຈັດອາຈົມ
ຖິ້ມອາຈົມລົງວິດຖ່າຍ	02		
ບໍ່ມີລູກນ້ອຍ (ອາຍຸ 3ປີລົງມາ) ຢູ່ໃນເຮືອນ	99		
ອື່ນໆ ____ (ໃຫ້ລະບຸ)	96		

S36	ພາຍໃນ 7 ວັນທີ່ຜ່ານມາ ມີຈັກເທື່ອທີ່ທ່ານ ຫຼືຄົນພາຍໃນເຮືອນຂອງທ່ານ ບໍ່ໄດ້ຖ່າຍໃສ່ວິດ?		
Coding categories	ຈຳນວນເທື່ອ	Go To	Remarks
ເວລາທີ່ບໍ່ຢູ່ເຮືອນ	7		
ເວລາທີ່ຫ້ອງນ້ຳບໍ່ຫວ່າງ	7		
ເວລາກາງຄືນ	7		

S41	ທ່ານລ້າງມືຂອງທ່ານຢູ່ໃສ?			
Coding categories	Yes	No	Go To	Remarks
ຍ້ອຍ ບໍ່ຍ້ອຍ / ບໍ່ເຄີຍ ລ້າງມື	1	3		ບໍ່ຍ້ອຍລ້າງ / ບໍ່ເຄີຍລ້າງ =>ໝາຍ Yes
ນອກເດີ່ນບ້ານ / ນອກຄອນຄືນ	5	7		
ຢູ່ນອກເຮືອນແຕ່ຢູ່ໃນບໍລິເວນບ້ານ	9	2		
ຢູ່ໃກ້ກັບຫ້ອງນ້ຳ	5	7		
ໃນຫ້ອງນ້ຳ	1	3		

S43	ຄົວເຮືອນດັ່ງກ່າວໃຊ້ວິທີການໃດໃນການເອົານ້ຳຈາກພາຊະນະບັນຈຸນ້ຳມາລ້າງມື?		
Coding categories		Go To	Remarks
ກົດ (ມາຈາກແທ້ງນ້ຳຫຼືນ້ຳປະປາ)	1		
ຖ້ວຍ/ບ່ວຍ (ເພື່ອຕັກນ້ຳ)	2		
ເອົາມືຈຸ່ມ / ເອົາມືກອບນ້ຳມາລ້າງ	3		
ຖອກຈາກຂວດ ຫຼື ກະຕຸກ	4		
ອື່ນໆ ____ (ໃຫ້ລະບຸ)	9		

ຕັ້ງແຕ່ນີ້ໄປໃຫ້ອາໄສການສັງເກດເທົ່ານັ້ນ (ຄຳຖາມ S51 ເຖິງ S57)

S51	ຂໍເບິ່ງນ້ຳດື່ມທີ່ຖືກເກັບກັກໄວ້ ແລະສັງເກດເບິ່ງວ່າການເອົານ້ຳມາດື່ມມີລັກສະນະແນວໃດ?			
Coding categories	Yes	No	Go To	Remarks
A) ມີຄວາມເປັນໄປໄດ້ທີ່ມືຈະສຳຜັດກັບນ້ຳດື່ມ	1	3		ອາດຖາມຂໍດື່ມນ້ຳແລ້ວສັງເກດເບິ່ງ
B) ສັງເກດເບິ່ງວ່າບ່ອນວາງ ຈອກ/ກະບອຍຕັກນ້ຳ ມີຄວາມສະອາດບໍ່ເປິະເປື້ອນຫຼືບໍ່?	5	7		

S52	ອຸປະກອນເກັບນ້ຳ (ຖ້າມີ) ມີຝາປິດຫຼືບໍ່?		
Coding categories		Go To	Remarks
ມີ	1		
ບໍ່ມີ	3		

S53	ຂໍເບິ່ງບ່ອນລ້າງມືຂອງຄົວເຮືອນ ແລະສັງເກດເບິ່ງວ່າມີວັດຖຸ ຫຼືອຸປະກອນຕ່າງໆດັ່ງລຸ່ມນີ້ຫຼືບໍ່?			
Coding categories	Yes	No	Go To	Remarks
A) ນ້ຳ	1	3		ຖ້າເຈົ້າຂອງບໍ່ສາມາດສະແດງສິ່ງຕ່າງໆເຫຼົ່ານີ້ພາຍໃນ 2 ນາທີ ໃຫ້ໝາຍ No
B) ສະບູ, ຂີ້ເຖົ່າ ແລະ/ຫຼື ອື່ນໆ	5	7		
C) ຊາມ, ຄຸ, ອ່າງລ້າງມື	1	3		

S54	ໄລຍະທາງລະຫວ່າງບ່ອນລ້າງມື ແລະ ຫ້ອງນ້ຳມີປະມານຈັກແມັດ?		
Coding categories		Go To	Remarks
ໄລຍະທາງຈາກບ່ອນລ້າງມື ຫາຫ້ອງນ້ຳ (ແມັດ)			ບໍ່ມີຫ້ອງນ້ຳ No toilet
ບໍ່ມີບ່ອນລ້າງມື ຫຼື ຫ້ອງນ້ຳ	99		

S55	ມີສິ່ງເສດເຫຼືອຂອງຄົນຕິດຢູ່ຕາມຊູ້ສ້ວມ/ຫົວສ້ວມ ຫຼືບໍ່?		
Coding categories		Go To	Remarks
ມີ	1		ບໍ່ມີຫ້ອງນ້ຳ No toilet
ບໍ່ມີ	3		

S56	ມີອາຈົມຂອງຄົນຢູ່ໃນ ຫຼື ຕາມບໍລິເວນອ້ອມແອ້ມເຮືອນຫຼືບໍ່?		
Coding categories		Go To	Remarks
ມີ	5		ຖ້າພົບສິ່ງເສດເຫຼືອມີລັກສະນະຄ້າຍອາຈົມ ຂອງ ຄົນ ໃຫ້ໝາຍ ມີ
ບໍ່ມີ	7		

S57	ມີຫຍັງທີ່ສະແດງໃຫ້ເຫັນວ່າຫ້ອງນ້ຳບໍ່ຖືກໃຊ້ເປັນປະຈຳຫຼືບໍ່?			
Coding categories	Yes	No	Go To	Remarks
A) ຖະໜົນໄປຫາຫ້ອງນ້ຳແປນບໍ່?	1	3		ບໍ່ມີຫ້ອງນ້ຳ No toilet
B) ຮີດຖ່າຍບໍ່ມີຮ່ອງຮອຍການໃຊ້ໃນໄລຍະໃກ້ໆນີ້ບໍ່?	5	7		ສຳລັບຂໍ້ B ໃຫ້ໝາຍ No ຖ້າເຫັນວ່າຮີດຖ່າຍມີຮ່ອງຮອຍການໃຊ້ໃນໄລຍະໃກ້ໆນີ້
C) ຫ້ອງນ້ຳຢູ່ບໍລິເວນອ້ອມແອ້ມເຮືອນຫຼືບໍ່?	9	2		

Pocket voting !!!

S58	ເວລາໃດທີ່ທ່ານລ້າງມືເປັນປະຈຳ?							
Coding categories	ບໍ່		ກ່ອນ		ຫຼັງ		ຈຳນວນຄົນທີ່ປ່ອນບັດ ທັງໝົດ	Remarks
	ຊ	ຍ	ຊ	ຍ	ຊ	ຍ		
A) ແຕ່ງກິນ/ກິນເຂົ້າ	1		1	2			4	
B) ໄປຫ້ອງນ້ຳ	2	2					4	
C) ລ້າງກົ້ນລູກ							00	

PV [redacted]

ET	ເວລາສຳເລັດການສຳພາດ (In 24h notation)	09	05

Appendix D Interview form in English

Vision 21 field trials Lao PDR Aug 2003 | Draft UK ver.06 | URI / LSHTM

Household information sheet for Vision 21 survey

SR	Survey reference: V 2 1 L A O	CI	Cluster ID	HHN House-hold N° H
PR	Province K H A M M U A N	VA	yes 1 / No 3	

DI District

Tha Khaek	02	Not used	12	Not used	24	Not used	34
Not used	04	Not used	14	Not used	26	Not used	36
Not used	06	Not used	16	Not used	28	Not used	38
Not used	08	Not used	18	Not used	30	Not used	44
Not used	10	Not used	22	Not used	32	Not used	46

VL Village

Chomcheng	01	Dongmouangkhai	17	Tham	35	Phonesa-aad	55
Chomphet	03	Dongsork	19	Thakhekkang	37	Phone-ngearnoi	57
Chomthong	05	Dornkheuanxang	21	Thakheknuea	39	Lammalad	59
Souksavanh	07	Dorndone	23	Thaduea	41	Vern	61
Somsanook	09	Dorn-ngai	25	Nakaikhia	43	Viengvilay	63
Xienglae	11	Doy	27	Nadone	45	Hadkham	65
Dornmouang	13	Tan	29	Bunghieng	47	Nongbuathong	67
Dongkommaketh	15	Tatthong	33	Phone-ngam	49	Nongphue	69

HU House Unit | NH House Number | Information as found on Blue plate

RN Home many different households live here ? | If more Households select ONE RANDOMLY

NH Name of the household interviewed

Describe how to find the household back, make sketch if needed and ask for name and telephone number or any other usefull information to contact and visit this household.

SV	Survey visits	1 2 3 4 5	SS	Survey status	Done	1	Non response	3	No BSU	5
VV	Validation visits	1 2 3 4 5	VS	Validat. status	Done	1	Non response	3	No BSU	5

Press <MARK> on GPS (you can use <AVERAGE> if wanted). Note down the information and **press <ENTER>**

GPS	GPS ref. N°:	EPE . m T	LA	Latitude (N+/S-)	
WP	Waypoint reference		LO	Longitude (E+/W-)	
MD	Map Datum	W G S 4 8	CF	Coordinates Format	h d d d . d d d d d

Lao PDR Ministry of Communication Transport Post and Construction, Urban Research Institute
London School of Hygiene and Tropical Medicine, Environmental Health Group

DC	Date data collection	0 3
S1	1st Surveyor ref.:	
VS2	2nd Surveyor ref.:	
VAC	Did data collection took place?	
Yes		5
No		7

DT	Type of data collected	
Interview (survey form used)		1
Structured observation (Validation form used)		3

If NO state reason:

Recommended date and time for revisit:

If ***Yes*** *reference of data collection forms!!!*

DC	Date data collection	0 3
S1	1st Surveyor ref.:	
S2	2nd Surveyor ref.:	
VAC	Did data collection took place?	
Yes		5
No		7

DT	Type of data collected	
Interview (survey form used)		1
Structured observation (Validation form used)		3

If NO state reason:

Recommended date and time for revisit:

If ***Yes*** *reference of data collection forms!!!*

DC	Date data collection	0 3
S1	1st Surveyor ref.:	
S2	2nd Surveyor ref.:	
VAC	Did data collection took place?	
Yes		5
No		7

DT	Type of data collected	
Interview (survey form used)		1
Structured observation (Validation form used)		3

If NO state reason:

Recommended date and time for revisit:

If ***Yes*** *reference of data collection forms!!!*

If an extra form is used tick here !! =>

Lao PDR Ministry of Communication Transport Post and Construction, Urban Research Institute
London School of Hygiene and Tropical Medicine, Environmental Health Group

Vision 21 survey questionnaire

GI	Gender of interviewee
Male	1
Female	3

MI	Maturity of interviewee
Adult (18 years or older)	5
Kid	7

HHS	Survey form N°	S

ST Start time interview [ ][ ] : [ ][ ] (Use 24H notation e.g. 5 am = 05:00, 5pm = 17:00)

S11	What is the main source of drinking water collected for your household yesterday?		
Coding categories		Coding categories	
PIPED WATER		SURFACE WATER	
Piped water in dwelling	11	River/Stream	42
Piped water in yard / plot	12	Pond / Lake / LARGE rain catchment	43
Piped water by public tap / standpipe	13	Dam	44
Illegal piped connection anywhere	14	Protected spring / Artesian well	41
WATER FROM OPEN WELL		Unprotected spring / Artesian well	45
Open well in dwelling	21	Rain catchment from roof	51
Open well into yard / plot	22	Tanker truck / house to house vendor	61
Open public well	23	Bottled water	71
FROM COVERED WELL OR BOREHOLE		Other: (Specify)	96
Protected well in dwelling	31		
Protected well into yard / plot	32	(If water source is **neighbours** source water source mark **yard/plot**)	
Protected public well	33		

All questions on the rest of this page are referring to the SOURCE MENTIONED ABOVE.

S12	How long did it take you yesterday to go there, get **this** drinking water, and come back?		
Coding categories		Go To	Remarks
Hours; Minutes (queuing included)	[ ][ ] h [ ][ ] m		
On premises or delivered at home	00		

S13	How many days you could not get this drinking water during the last seven days?		
Coding categories		Go To	Remarks
Number of days water was not available			
Water was every day available	0	**S14**	

S13b	What were the reasons you could not get **this** drinking water during the last seven days?				
Coding categories	Yes	No	Coding categories	Yes	no
1) Could not pay for it	1	3	5) Your health did not allow you to collect	1	3
2) Had no time to collect water	5	7	6) Did not need any, Had enough	5	7
3) Not enough pressure	9	2	7) Other (Specify)	9	2
4) Too long queues	4	6			

S14	Can **this** drinking water source be used during the whole year round?		
Coding categories		Go To	Remarks
Yes, used during the whole year	1	**S16**	
No, can not always be used	3		

S15	Which are the months you can not use this source of drinking water?							
Coding categories	Can	Not	Coding categories	Can	Not	Coding categories	Can	Not
January	1	3	May	1	3	September	1	3
February	5	7	June	5	7	October	5	7
March	9	2	July	9	2	November	9	2
April	4	6	August	4	6	December	4	6

Mark **Not** to ALL the months this source is not available!

S16	Do you treat the collected water before drinking? (Household treatment only)		
Coding categories		Coding categories	
Not treated at all	11	Chlorination	21
Sedimentation	13	Flocculation (Alum, Moringa)	23
Boiling	15	Solar disinfection	25
Filtered with cloth	17		
Fine filtering (Ceramic, Sand)	19	Other: (Specify)	96

S21	Do you use a different source of water for personal hygiene such as washing?		
Coding categories		Go To	Remarks
Yes, I use different water sources.	1		
No, I use only one water source.	3	next page	

S22	What is the main source of non drinking water for members of your household?		
Coding categories		Coding categories	
PIPED WATER		SURFACE WATER	
Piped water in dwelling	11	River/Stream	42
Piped water into yard / plot	12	Pond / Lake / LARGE rain catchment	43
Piped water by public tap / standpipe	13	Dam	44
Illegal piped connection anywhere	14	Protected spring / Artesian well	41
WATER FROM OPEN WELL		Unprotected spring / Artesian well	45
Open well in dwelling	21	Rain catchment from roof	51
Open well into yard / plot	22	Tanker truck / house to house vendor	61
Open public well	23	Bottled water	71
FROM COVERED WELL OR BOREHOLE		Other: (Specify)	96
Protected well in dwelling	31		
Protected well into yard / plot	32	(If water source is **neighbours** source water source mark **yard/plot**)	
Protected public well	33		

S23	How long does it take you to go there, get non-drinking water, and come back?		
Coding categories		Go To	Remarks
Hours; Minutes (queuing included)	h m		
On premises	00		

S24	How many days was non-drinking water NOT available during the last seven days?		
Coding categories		Go To	Remarks
Number of days water was not available			
Water was every day available	0		

S24b	What where the reason you could not get **this** non-drinking water during the last seven day				
Coding categories	Yes	No	Coding categories	Yes	no
Could not pay for it	1	3	Your health did not allow you to collect	1	3
Had no time to collect water	5	7	Did not need any, Had enough	5	7
Not enough pressure	9	2	Other	9	2
Too long queues	4	6	(Specify)		

S25	Can this source of non drinking water be used during the whole year?		
Coding categories		Go To	Remarks
Yes, used during the whole year	1		
No, can not always be used	3		

S26	Which are the months you can not use this source of non-drinking water?							
Coding categories	Can	Not	Coding categories	Can	Not	Coding categories	Can	Not
January	1	3	May	1	3	September	1	3
February	5	7	June	5	7	October	5	7
March	9	2	July	9	2	November	9	2
April	4	6	August	4	6	December	4	6

Mark **No** to ALL the months this source is not available!

Where do you dispose of your stools?

S31	What kind of toilet facilities does your household use?		
Coding categories		**Go To**	**Remarks**
FLUSH TOILETS			
Flush to sewage system or septic tank.	11		
Pour flush latrine (water seal type)	12		
PIT TOILET / LATRINE			
Open pit latrine	21		Pit which is not fully covered
Covered pit latrine	22		Pit with a cover and drop hole
Ventilated improved pit latrine	23		Covered pit with ventilation pipe
No facilities/bush/field/flying toilets	31		
Buried or cover the faeces	32		Improved traditional practice
Bucket, night soil or service latrine	41		
Overhung (long) Latrine	42		
Other:________ (Specify)	96		

S31b	How long does it take from your home to go to the place you defecate?		
Coding categories		**Go To**	**Remarks**
Going from home to where I defecate takes me | | |	min.		One leg only

S32	Who do you share these facilities with?		
Coding categories		**Go To**	**Remarks**
Nobody, the facility is only used by the household	1		
Some households, we share the same facilities	3		
Everybody can use it, it is a public facility	7		

S34	Do you pay EACH TIME you use these facilities?		
Coding categories		**Go To**	**Remarks**
Yes, I pay each time I use the toilet	1		Pay-as-you-go
No, I pay a periodical fee (e.g. monthly)	3		Pay a rate over a period
No, I pay nothing at all	5		Free toilet

S35	What has been done to dispose of your youngest child's stools/ diapers the last time he/she did not use any toilet facilities?		
Coding categories		**Go To**	**Remarks**
Child always uses toilet	01		
Thrown into toilet	02		
Thrown outside the dwelling (inside the yard)	03		
Thrown outside the yard	04		
Buried in the yard	05		
On a waste heap, in open waste pit or - bin	11		Open burning in this category.
In a covered bin for regular collection	12		*If not collected regularly or if potty or diaper is used mark where it or its content is disposed of.*
Rinsed away in sink or drain	06		
Not disposed of or left in a defecation area	09		
No young children (0-3) years in household	99		
Other:________ (Specify)	96		

S36	How many days in the last seven days did you practice open defecation.		
		Go to	
A) When away from the house	3		
B) When facility is occupied	7		
C) At night	3		

S41	Where do you have places to wash your hands?			
Coding categories	**Yes**	**No**	**Go To**	**Remarks**
A) Rarely / never	1	3		Rarely/never wash my hands mark this.
B) outside plot	5	7		
C) In de compound	9	2		
D) Close to the toilet	4	6		
E) Inside the toilet	1	3		

S43	What does the household use as a drawing mechanism for drinking water?	
Coding categories	Go To	Remarks
Tap (on a tank or piped water) 1 Cup or ladle (to scoop out water) 2 Hands 3 Pour from bottle or jerrycan 4 Other: ______ (Specify) 9		

From here onwards you will have to make OBSERVATIONS only!!!

S51	Ask to see the stored drinking water, and observe the way the water is drawn from the container!			
Coding categories	Yes	No	Go To	Remarks
A) Is it likely that hands get in contact with the drinking water?	1	3		Ask for drinking water or for a demonstration if needed!
B) Is the cup/ladle kept in a dedicated place free from contamination?	5	7		

S52	Is the water container (if any) covered ?	
Coding categories	Go To	Remarks
Yes it is covered 1		
No it isn't covered 3		

S53	Ask to see the place where people usually wash there hands and see if the following items are present?			
Coding categories	Yes	No	Go To	Remarks
A) Water	5	7		If people can not show the items in ±2 minutes after prompting mark NO!
B) Soap, ash, or other cleansing agent	9	2		
C) Basin, Bucket, Sink	4	6		

S54	How many meters (paces) is there between the place for hand washing and the toilet?	
Coding categories	Go To	Remarks
Distance between hand washing place and toilet (m) ☐☐		
No toilet or hand washing place 99		

S55	Is the drop hole / closet free from visible excreta? (At places where there should not be any)	
Coding categories	Go To	Remarks
Yes it is 1		
No it is not 3		

S56	Are there children's faeces in or around the household area?	
Coding categories	Go To	Remarks
Yes, there are faeces around the household area. 5		Any faeces of apparently human origin are considered!
No, there are no faeces around the household area. 7		

S57	Does the toilet shows signs of regular use and has good access?			
Coding categories	Yes	No	Go To	Remarks
A) Road to toilet is clear and used?	1	3		
B) Cubicle shows signs of it NO recent used?	5	7		
C) Is the toilet within the compound?	9	2		

Pocket voting !!!

S58	When do they usually <u>wash</u> your hands?						
Coding categories	NOT		Before		After		Remarks
	M	F	M	F	M	F	
A) Handling food (cooking/eating)							
B) Going to the toilet							
C) Cleaning child's bottom							

ET	End Time Interview (in 24h notation)	☐☐	☐☐

London School of Hygiene and Tropical Medicine, Environmental Health Group Page 4 of 4

Appendix E: Structure observation forms in Lao

Vision 21 Field Trials. Lao PDR, August 2003 H 4044 Final Lao Version V 01

Vision 21 Household Validation Sheet (ແບບຟອມສັງເກດ)

VQR	Form ref.	V 2026

VST	ເວລາເລີ່ມການສັງເກດ	6 : 25	(Use 24H notation e.g. 5 am = 05:00, 5pm = 17:00)

V11 ຈຳນວນຄົນທີ່ມີໜ້າໃນເວລາເລີ່ມການສັງເກດ

ຜູ້ໃຫຍ່				ເດັກອາຍຸສູງກວ່າ 5 ປີຂຶ້ນໄປ				ເດັກອາຍຸຕ່ຳກວ່າ 5 ປີ			
AM] ຊາຍ	1	AF] ຍິງ	1	OM] ຊາຍ	1	OF] ຍິງ	1	UM] ຊາຍ		UF] ຍິງ	

V21 ຄົນຢູ່ໃນຄົວເຮືອນໃຊ້ວິດຖ່າຍບໍ່ — Y / N / ? (Y)

V22 ຖ້າມີຫ້ອງນ້ຳ, ຫ້ອງນ້ຳຕັ້ງກ່າວຢູ່ໃນເຮືອນຫຼືບໍ່? — Y / N / ? (N)

V23 ຖ້າບໍ່ຢູ່ໃນເຮືອນ, ມັນຢູ່ຫ່າງຈາກເຮືອນປະມານຈັກແມັດ? — 8 m

V24 ຮູວິດ / ທໍ່ສ້ວມມີອາຈົມຂອງຄົນຫຼືບໍ່?

ບໍ່ມີອາຈົມ	1	ມີຮ່ອງຮອຍຂອງອາຈົມຕິດຢູ່	3	ມີໜ້ອຍໜຶ່ງ	5	ມີຫຼາຍ	7

V25 ຫ້ອງນ້ຳມີກິ່ນເໝັນຫຼືບໍ່?

ບໍ່ມີເລີຍ	1	ໜ້ອຍໜຶ່ງ	3	ເໝັນຫຼາຍ	5	ເໝັນຈົນຫາຍໃຈບໍ່ໄດ້	7

V28 ຕ້ອງໄດ້ຈ່າຍເງິນບໍ່ເພື່ອໃຊ້ຫ້ອງນ້ຳ?

ບໍ່	1		3		5	ຕ້ອງຈ່າຍ	7

V29 ສັງເກດເຫັນອາຈົມຂອງຄົນຢູ່ໃນ ຫຼື ບໍລິເວນອ້ອມແອ້ມເຮືອນຫຼືບໍ່?

ບໍ່ເຫັນ, ສະອາດດີ	1	ເຫັນ, ແຕ່ຖືກມັດນໂດຍໄວ	3	ເຫັນ, ມີຈຳນວນໜຶ່ງ	5	ເຫັນ, ມີຫຼາຍ	7

V30 ການກຳຈັດອາຈົມຂອງຄົນໃນເວລາທຳການສັງເກດ

	ໃຜ? A/O/U	ຊ/ຍ	ເວລາ? (24H)	ສະຖານທີ່?	ລ້າງມື? Y/N	ຖູກຖູມືຢ່າງນ້ອຍ 3ເທື່ອ? Y/N	ໃສ່ສະບູ? Y/N	ໄລມື? Y/N	ປ່າງບ້ອຍນ້ຳບອຍ? Y/N	ຂໍ້ສົດເຫັນອື່ນໆ?(ຂອບ ໃສ່ ເຈັບຕ່າງຫາກ)
	A F	ຍ	6H40	[illegible]	Y	Y	Y	Y	Y	
B	O M	?	7H	[illegible]	Y	Y	N	Y	Y	
C										
D										
E										
F										

V31 ເຈົ້າເຈົ້າກຳຈັດອາຈົມຂອງເດັກນ້ອຍດ້ວຍວິທີໃດ? [illegible]

	ໃຜເຮັດ? A/O/U	ຊ/ຍ	ເວລາ? (24H)	ສະຖານທີ່ກຳຈັດອາຈົມ?	ນ້ຳທີ່ໃຊ້ສະລ້າງເດັກນ້ອຍຖິ້ມໃສ?	ລ້າງມື? Y/N	ຖູກຖູມືຢ່າງນ້ອຍ 3ເທື່ອ? Y/N	ໃສ່ສະບູ? Y/N	ໄລມື? Y/N	ປ່າງບ້ອຍນ້ຳບອຍ? Y/N	ຂໍ້ສົດເຫັນອື່ນໆ?
A											
B							No	small	Child		
C											
D											

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V32 ການທຳຄວາມສະອາດເດັກຫຼັງຈາກຖ່າຍໜັກ [illegible]

	ໃຜເຮັດ? A/O/U	ຊ/ຍ	ເວລາ? (24H)	ສະຖານທີ່ທຳຄວາມສະອາດເດັກ?	ນ້ຳທີ່ໃຊ້ລະລ້າງເອົາໄປຖິ້ມໃສ?	ລ້າງມື? Y/N	ຖູມືຢ່າງນ້ອຍ 3ເທື່ອ? Y/N	ໃສ່ສະບູ? Y/N	ໂລມື? Y/N	ປ່າງນ້ອຍນ້ຳບອຍ? Y/N	ອື່ນໆ?
A											
B						No	small	child			
C											

V41 ເຈົ້າເຈົ້າເຮັດແນວໃດກັບສິ່ງແປດເປື້ອນກັບອາຈົມ ເຊັ່ນວ່າຜ້າອ້ອມ, ຟືນ, ອື່ນໆ? , [illegible]

	ໃຜເຮັດ? A/O/U	ຊ/ຍ	ເວລາ? (24H)	ມັນແປດເປື້ອນໃສ່ໃສ?	ມັນຖືກທຳຄວາມສະອາດບໍ່ Y/N?	ລາຍລະອຽດ :
A						
B						

V42 ແຕ່ງກິນ/ກິນເຂົ້າ, ການເບິ່ງແຍງແຄນ້ອຍ ແລະ ການລ້າງມື

	ໃຜ? A/O/U	ຊ/ຍ	ເວລາ? (24H)	ກິດຈະກຳ? ແຕ່ງກິນ, ເບິ່ງແຄນ້ອຍ, ອື່ນໆ	ລ້າງມື? Y/N	ຫຼັງ/ກ່ອນ	ຖູມືຢ່າງນ້ອຍ 3ເທື່ອ? Y/N	ໃສ່ສະບູ? Y/N	ໂລມື? Y/N	ປ່າງນ້ອຍນ້ຳບອຍ Y/N?	ອື່ນໆ?
A	A	ຊ	7H25	ກິນເຂົ້າ	y	ກ	y	N	y	y	
B	A	ຍ	7Hrs	ກິນເຂົ້າ	y	ຫຼັງ	N	N	y	y	
C	O	ຍ	11H20	[illegible]	y	ຫຼັງ	y	y	y	y	
D	O	ຊ	12H	ກິນເຂົ້າ	y	ຫຼັງ	N	N	y	y	
E											
F											
G											
H											
I											
J											
K											
L											
M											
N											
O											

V52 ກິດຈະກຳອື່ນໆ ແລະ ການລ້າງມື

	ໃຜ? A/O/U	ຊ/ຍ	ເວລາ? (24H)	ກິດຈະກຳ?	ລ້າງມື? Y/N	ຫຼັງ/ກ່ອນ	ຖູມືຢ່າງນ້ອຍ 3ເທື່ອ? Y/N	ໃສ່ສະບູ? Y/N	ໂລມື? Y/N	ປ່າງນ້ອຍນ້ຳບອຍ Y/N?	ອື່ນໆ?
A	O	ຍ	11H	ກວາດເຮືອນ	y	ຫຼັງ	N	N	y	y	
B	O	ຊ	11H25	[illegible]	N	–	N	N	[illegible]	N	
C	A	ຊ	11H30	ລັບພ້າ	y	ຫຼັງ	N	N	y	y	
D											

V43	ການໄປຕັກເອົານ້ຳ					
	ໃຜ? A/O/U	ລ/ດ	ເວລາ? (24H)	ປະເພດແຫລ່ງນ້ຳ?	ໃຊ້ຕື່ມບໍ່ Y/N?	ໄລຍະເວລາ (ນາທີ): (ລວມເວລາຖ້າ)	ຂໍ້ຄິດເຫັນອື່ນໆ? (ຂອບ ໃສ່ເຈັຍຕ່າງຫາກ)
A	O	5	10H15	ນ້ຳສ້າງ	Y	5	
B							
C							
D							
E							
F							

V44	ນ້ຳດື່ມຖືກເກັບຮັກສາໄວ້ໃນເຮືອນຫຼືບໍ່?	Y / N / ?

ຖ້າແມ່ນ

V45	ນ້ຳດື່ມຖືກເກັບມ້ຽນຢູ່ບ່ອນມີຫລັງຄາມຸງຫຼືບໍ່?	Y / N / ?
V46	ມີຝາປິດພາຊະນະບັນຈຸນ້ຳດື່ມຫຼືບໍ່?	Y / N / ?

V47	ມີການບຳບັດນ້ຳກ່ອນດື່ມຫຼືບໍ່ (ການບຳບັດທີ່ຄົວເຮືອນເຮັດເອງ)?	Y / N / ?

ຖ້າມີ

ໃຫ້ບອກລາຍລະອຽດວິທີການບຳບັດ :

V50	ການຕັກນ້ຳມາດື່ມ							
	ໃຜ? A/O/U	ລ/ດ	ເວລາ? (24H)	ປະເພດຂອງພາຊະນະບັນຈຸ? (ຖັງ,ຂວດ,ຝຸຍ...)	ໃຊ້ນ້ຳເພື່ອ (ດື່ມ,ລ້າງ)	ພາຊະນະໃຊ້ບໍ?	ມີຝາປິດບໍ? Y/N	[illegible] Y / N	[illegible] Y / N
A	A	2	7H35	ກະຕິກນ້ຳ	ດື່ມ	ລວມ	N	Y	Y
B	O	2	12H10	ກະຕິກນ້ຳ	ດື່ມ	ລວມ	N	Y	Y
C	O	3	12H15	ກະຕິກນ້ຳ	ດື່ມ	ລວມ	N	Y	Y
D									
E									
F									
G									
H									
G									

V51	ມີຮ່ອງຮອຍຄວາມບໍ່ສະອາດຕາມບໍລິເວນອ້ອມແອ້ມເຮືອນບໍ່? (ຂີ້ເຫຍື້ອ, ນ້ຳຂັງ ອື່ນໆ)	Y / N / ?

ຖ້າມີ

ລະບຸລາຍລະອຽດ :

- ມີຂີ້ງົວ - ຂີ້ຄວາຍ ຕາມເສັ້ນທາງ
- ມີນໍ້າຂັງ ເປິເປື້ອນ [illegible]

V53	ມີຫຍັງຕື່ມທີ່ສັງເກດເຫັນຫຼືບໍ່?	Y / N ?

ຖ້າມີ

ລະບຸລາຍລະອຽດ :

VET	ເວລາສຳເລັດການສັງເກດ (in 24h notation)	12 : 20

Appendix F Structure observation forms in English

Vision 21 field trials Lao PDR Aug 2003 Draft UK ver. 06 URI / LSHTM

Vision 21 survey HOUSEHOLD VALIDATION form

VST	Start time of observation	HHV	validation Form ref. V

V11	Number of people present at the start of the interview.										
Adults				Children over 5 years				Children under 5 years			
AM] male		AF] female		OM] male		OF] female		UM] male		UF] female	

V21	Do the people in the household use an excreta disposal facility?	Y / N / ?
V22	If there is a 'toilet' is it in the house?	Y / N / ?
V23	If not in the house how far is it from the residence (single leg in m or passes)	m

V24	Is the drop hole / closet, floor or wall free from visible excreta?		
Yes, it is free 1	No, there are traces 3	There is some 5	There is quite a lot 7

V25	Does the 'toilet' smell (stinks)?		
No, not at all 1	Yes, slightly 3	Stinks a lot 5	Stinks unbearably 7

V28	Is there any payment for the use of the toilet?		
No 1	3	5	Yes, pay each time 7

V29	Can you see any human faeces in or around the household?		
No, all is clean 1	Yes, but quickly cleaned 3	Yes, some faeces 5	Yes, a lot of faeces 7

V30 Excreta disposal during observation:

	Who? A/O/U	M/F	Time? (24H)	Where?	Wash hands? Y/N	Rub hands min.3X? Y/N	Use soap? Y/N	Min ½ of water? Y/N	Comments: (Add additional comments on separate paper!)
A									
B									
C									
D									
E									

V31 Children faeces and / or use of potty:

	Who? A/O/U	M/F	Time? (24h)	Where're faeces disposed?	Where is cleaning water disposed?	Wash hands? Y/N	Rub hands min 3X? Y/N	Use soap? Y/N	Min.½ of water? Y/N	Comments? (On note pad)
A										
B										
C										

V32 Cleaning child after defecation:

	Who handles? A/O/U	M/F	Time? (24h)	Where're faeces disposed?	Where is cleaning water disposed?	Wash hands? Y/N	Rub hands min 3X? Y/N	Use soap? Y/N	Min.1mug of water? Y/N	Comments? (On note pad)
A										
B										
C										

V41 What is done with other faecal contamination like cloths, floors etc.

	Who? A/O/U	M/F	Time? (24h)	What type of 'contamination'?	cleaned Y/N?	Details:
A						
B						

V42 Handling food including eating and weaning and handwashing!

	Who? A/O/U	M/F	Time? (24h)		Wash hands? Y/N	Before / After	Rub hands min 3X? Y/N	Use soap? Y/N	Min.1mug of water? Y/N	Comments: (On note pad)
A										
B										
C										
D										

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V43	Water collection!						
	Who? A/O/U	M/F	Time?	Source type?	Drinking water? Y/N	Duration (min): (Queuing inc.)	Comments: (Add additional comments on note pad)
A							
B							
C							
D							

V44	Is DRINKING water stored in the household?	Y / N / ?
If yes, V45	Is drinking water stored indoors?	Y / N / ?
V46	Is the drinking water container covered?	Y / N / ?
V47	Is any water treatment used at the household level for drinking water?	Y / N / ?

If yes, give details

____

____

____

V50	Drinking water drawing and handling!									
	Who? A/O/U	M/F	Time?	Type of storage? (Container, bottle, tank, drum ...)	Water use? (drinking, washing)	Drawing type? (cup, ladle tap, hands)	Hands touch stored water? Y/N	Paid Y/N?	Drawing recipient has dedicated place? Y / N	Recipient is stored away from potential contamination? Y / N
A										
B										
C										
D										

V51	Are there other signs of less favourable environment? (Rubbish, stagnant water ..)	Y / N / ?

If yes, give details:

____

____

____

V52	Other activities and hand washing.									
	Who? A/O/U	M/F	Time? (24h)	Activity?	Wash hands? Y/N	Before / After	Rub hands min.3X? Y/N	Use soap? Y/N	Min 1 mug of water? Y/N	Comments: (Add comments on the back!)
A										
B										
C										
D										
E										
F										

V53	Any other practices you would like to mention or remarks you would like to make?	Y / N

If yes, give details.

____

____

____

VET	End Time observation (in 24h notation)				

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Pete Kolsky
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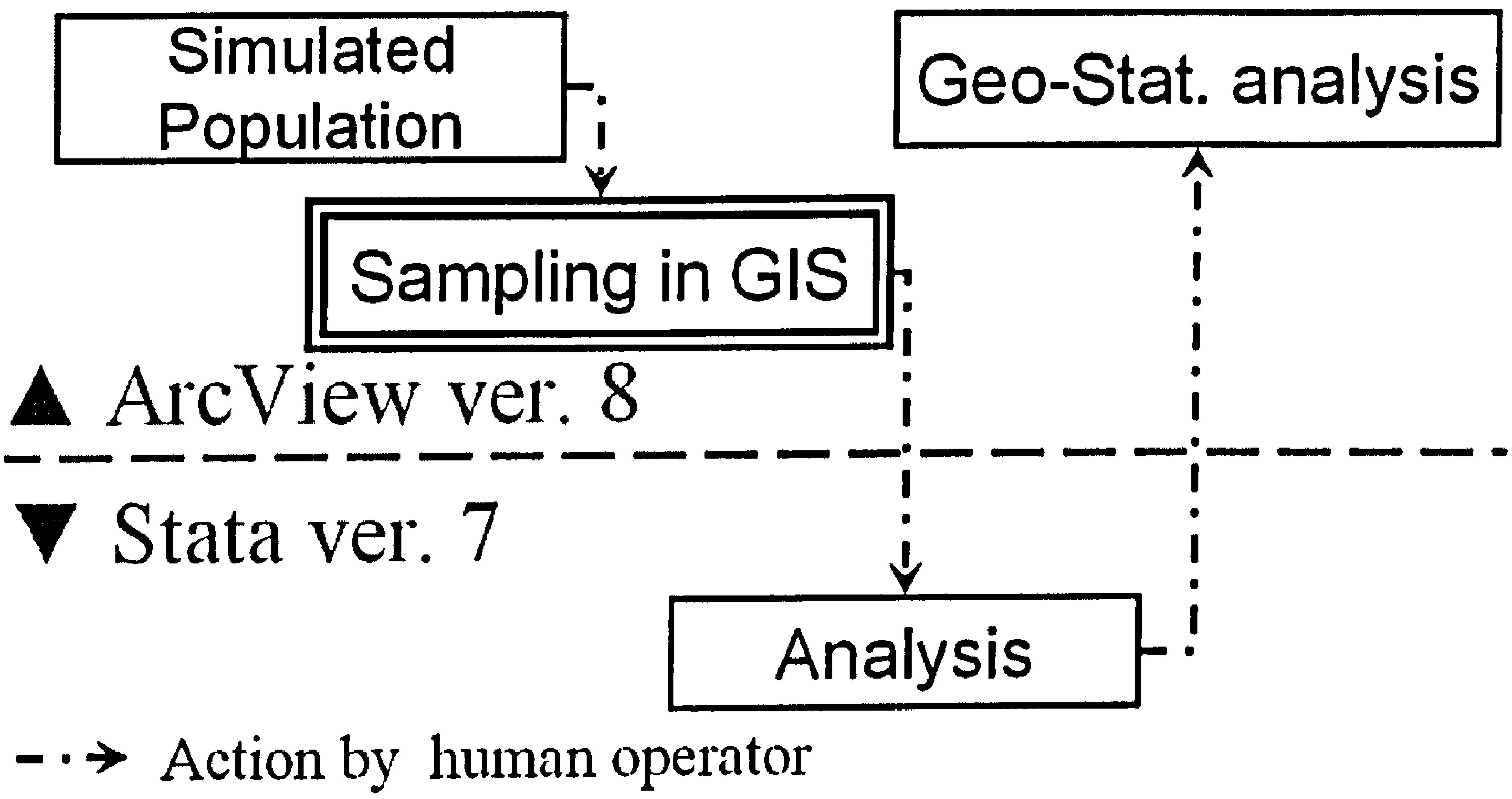
January 21, 2004 9:46 AM

The Forms used in the Lao survey can be found at the end of the Lao report in annexJ


Simulated Population
Geo-Stat. analysis
Sampling in GIS
▲ ArcView ver. 8
▼ Stata ver. 7
Analysis
Action by human operator

Annex M Publication by the author directly related to the thesis

M1: Publication in the "International Journal of Epidemiology"

M2: Papers submitted to "Emerging Themes in Epidemiology" for a special issues on "Methodological Issues in Field Surveys"

Published by Oxford University Press on behalf of the International Epidemiological Association
International Journal of Epidemiology 2006;35:751–755

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Optimization of household survey sampling without sample frames

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There are a few sampling methods available to survey households in situations where sample frames are either unavailable or are unreliable. The most popular of these methods is the expanded programme of immunization (EPI) sampling method, which has been used in low-income countries. The purpose of this paper is to explain how mathematical programming can be used to optimize EPI and other household survey sampling methods in these situations.

Keywords Expanded program for immunization, survey methods, household sampling, mathematical programming

Representative samples in household surveys are often difficult to obtain in low-income countries. Traditional sampling methods based on simple random sampling (SRS) give each Basic sampling unit (BSU) an equal probability of inclusion in the sample. Although SRS is conceptually simple, applying it to household surveys can be expensive and unfeasible because it requires all the households to be identified prior to the sampling. The cluster sampling methods commonly used in household surveys reduce the need for detailed lists of households to the selected clusters. However, creating these lists (known as sample frames) still requires considerable effort, skill, and resources, which are not always available in low-income countries. The sample frames may not be reliable in situations where (i) maintaining the household lists proves difficult (often due to a lack of administrative structure for reporting changes), (ii) minorities, disadvantaged communities, or migrants tend to be excluded, and (iii) there is a high rate of migration, as in peri-urban areas or among populations displaced because of events such as natural disasters. Alternative household sampling methods, which do not use detailed sample frames, have been developed to cater for such situations.

EPI sampling method

To date one of the most popular spatial sampling methods adopted by WHO for use in low-income countries is the EPI method, named after the Expanded Programme of Immunization. This makes use of a modification of PPS (Probability Proportional to Size) sampling developed originally in the USA[1] and modified for use in the smallpox eradication programmes in West Africa.[2]

The EPI method can be described simply as follows. A number of clusters (e.g. communities, villages) are chosen with a probability proportionate to their size, and then an equal number of selected households is surveyed in each of the selected clusters. In each chosen cluster the EPI method selects (i) a location near the centre of the community, (ii) a random direction (which is often defined in the field by spinning a bottle or pen), and (iii) a random household along the chosen direction pointing outwards from the centre of the community to its boundary. In subsequent steps, which are carried out iteratively, the closest household (door to door) to that determined in the previous step is chosen and checked for compliance with the inclusion criteria. The iterations are repeated until the required number of households is surveyed.

There is no doubt that EPI-sampling (as this method is generally known) has been instrumental in evaluating immunization coverage worldwide. However statisticians had some concerns on the bias and precision of the estimates obtained using the EPI method until computer simulations provided some indications of its validity.[3,4] EPI-sampling has enabled WHO and UNICEF to measure the coverage of their childhood immunization programmes and has also been adapted to measure nutritional status.[5]

The simplicity and ease of applying EPI-sampling has made this method very popular. Unfortunately this method has often been used inappropriately owing to the lack of understanding of its statistical and analytical limitations as well as the lack of appropriate alternative sampling methods.[6,7] The use of EPI-sampling has, therefore, on occasions resulted in non-representative data on which perhaps erroneous

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decisions and conclusions were made. Suggestions have been made to improve and adapt the EPI method.[4,8-10] However, most of these improvements resulted in undermining the simplicity of the original method. Furthermore, it is difficult to assess whether these improvements resulted in more representative data.

The difficulties hindering further developments of the EPI and other sampling methods are mainly attributable to the fact that (i) the performance measure used to quantify improvements in the sampling method is ill-defined, (ii) there is a multitude of scenarios of household distribution on which the sampling method requires verification and validation, and (iii) it is not apparent how to analyse the properties of a sampling method that is not strictly random unless an exhaustive set of simulations are carried out. Furthermore a sampling method that is optimal in one scenario of household distribution could be sub-optimal or even inefficient in another scenario.

Note that the EPI design of 30 × 7 (30 clusters × 7 samples) was originally intended for measuring vaccination coverage in children aged between 12 and 23 months. This narrow age-specified inclusion criterion determines the parameters of the EPI design in terms of the density of the sampling and its geographical spread as on average it is expected that one in every seven households has a child aged between 1 and 2 years. Nutritional surveys, however, focus on children <5 years old. Because children in this wider age range are expected to be present in most households, this inclusion criterion reduces significantly the geographical spread of the sample. To compensate (albeit partially) for the clustering effect, the sample size in each cluster is increased for nutritional surveys from 7 to 30 (30 clusters × 30 samples), which in turn increases the design effect (*deff*) of the sample.[11]

Problems also arise with EPI sampling in mortality surveys. Owing to lack of an unbiased inclusion criterion, the sample becomes geographically highly clustered. Any outcome measure, which is highly clustered, can lead to high design effects (*deff* > 2).[12] A design effect of 2 is often assumed when no estimates of *deff* are available and is the value assumed in the original EPI design.[6]

Larger design effects can be found in household surveys measuring the provision of health services and access to water and sanitation. Clusters that include a health centre or a water point will have substantially higher access figures than those that do not have health or water provision services. In these studies, there is the additional problem that methods such as EPI sampling, which rely on PPS for the selection of clusters, can introduce selection bias; smaller sized clusters have less chance of being selected when using PPS, however clusters can be small because of lack of provision of services and so the selection may be erroneously biased against them.

The EPI method limits the design decisions to the number of clusters and the number of households within a cluster, and to defining the sequential choice of households for surveying within a cluster. Indeed, neither the sample size nor the strategy for selecting households are optimized in any sense. To validate EPI, past work used either hypothetical scenarios in which clusters and households are generated artificially through computer simulations[3,13] or real scenarios generated from data-rich surveys.[4]

Mathematical programming

Mathematical programming methods could be used to optimize household survey sampling methods in settings where sample frames are unavailable or impractical as is common in developing countries. Several sampling methods such as those of the EPI have been used in such situations. Simulations are often used to improve the statistical robustness of these methods, evaluating their sampling properties under different computer generated spatial distributions simulating realistic scenarios. We propose that mathematical programming would be more efficient in improving sampling methods by circumventing the need to use computing-intensive methods such as Monte Carlo simulations and by optimizing (rigorously and explicitly) the sampling methods through minimizing a sampling error term while constraining the survey cost or data collection time.

We propose the use of mathematical programming as a more meticulous approach to assessing various sampling methods. Mathematical programming is a branch of mathematics that deals with the formulation of optimization problems and the development and use of procedures (algorithms) to solve these problems. In its most basic form, an optimization problem is a mathematical description of a system (or a scheme) that is characterized by (i) a set of variables (known as control or optimization variables) whose values can be changed to achieve preset objectives, (ii) a performance measure (which depends on the control variables), and (iii) a set of constraints (which also depend on the control variables). By definition, the solution of an optimization problem is the set of values of the control variables that optimize (i.e. maximize or minimize) the performance measure while ensuring that the constraints are satisfied.

To illustrate the use of mathematical programming in this application, the household sampling problem is formulated as an optimization problem. The description below is not unique as several formulations are possible depending on the objectives of the sampling method. One of the advantages of the mathematical programming approach is that it allows alternative formulations to be compared in a straightforward manner.

The optimization problem is constructed in three main steps. The first step defines the control variables. These variables could be (i) the number of clusters, (ii) the number of households within a cluster, (iii) the spatial location of the starting point of the survey, and (iv) the 'survey pathway' or the spatial sampling strategy. The survey pathway is defined as the line constructed from joining together directed straight line segments (i.e. vectors) connecting consecutive households in the order they are surveyed.

The second step defines the performance measure to be optimized, for example the total error of the sample mean estimate. The square of the total error is the sum of two terms: the first term (bias) is the squared deviation of the sample mean estimate from that obtained by the 'gold standard' SRS sampling and the second term is the sample variance.[14] Other

Table 1 Description of optimization problem

In words	Mathematically
Minimize (total error) using (control variables)	$\min\limits_{(n,m,\vec{\varphi}_1,\ldots\vec{\varphi}_m)} \left(\Psi\left(n,m,\vec{\varphi}_1,\ldots\vec{\varphi}_m\right)\right)$
Subject to the following constraints being satisfied:	
Constraint 1: (cost) Survey cost ≤ budget	$c\left(n,m,\sum_{1}^{m}\delta\left(\vec{\varphi}_i\right)\right)\leq\alpha$
Constraint 2: (geographical) Spatial distribution of households geographical barriers	$\left(\vec{\varphi}_1,\ldots\vec{\varphi}_m\right)\in Z$

sampling error terms could be used depending on the context of the problem.

The third step defines the set of constraints to be satisfied. These could be divided into two sets. The first set of constraints is associated with the cost of the survey or the time taken for data collection. These constraints are often represented as inequalities. For example, it could be required that the cost of the survey does not exceed a fixed budget. The second set of constraints is associated with the geographical setting. Although they are referred to as constraints, these relationships model the spatial distribution of the households and the presence of any geographical barriers. They are called constraints *per se* because the geographical distribution of the households confines the survey pathway to some routes (i.e. restrict the feasible set of control variables).

The optimization problem can be represented in a compact form. Table 1 defines the optimization problem in words and represents it mathematically.

The mathematical representation captures in a snapshot the whole optimization problem by specifying the set of control variables, the performance measure to be optimized and the set of constraints to be satisfied. In this representation,

- Ψ is the total error of the sample mean estimate, the measure to be optimized.
- $n, m, (\vec{\varphi}_1, \ldots, \vec{\varphi}_m)$ are the control variables whose optimal values are to be determined.
- n is the number of clusters.
- m is the number of households within a cluster (assumed in this problem formulation to be the same for all clusters).
- $(\vec{\varphi}_1, \ldots, \vec{\varphi}_m)$ is the survey pathway where
- The arrow sign means that each line segment is a vector.
- $\vec{\varphi}_i$ is the vector (in two-dimensional Euclidean space $\Re^2$) connecting household $i-1$ to household i (note that $\vec{\varphi}_1$ is the vector connecting the starting point of the survey to the first household).
- $\delta(\vec{\varphi}_i)$ is the magnitude of the vector $\vec{\varphi}_i$, it represents the distance covered between a pair of consecutive households.
- c is the cost of survey.
- α is the maximum budget allocated for the survey. The inequality $c \leq \alpha$ ensures that that the cost does not exceed the budget.
- Z is the feasible set of the survey pathway. Z models the spatial distribution of the households (the spatial pattern describing the scatter of the households in two dimensions) and possibly any geographical barriers.

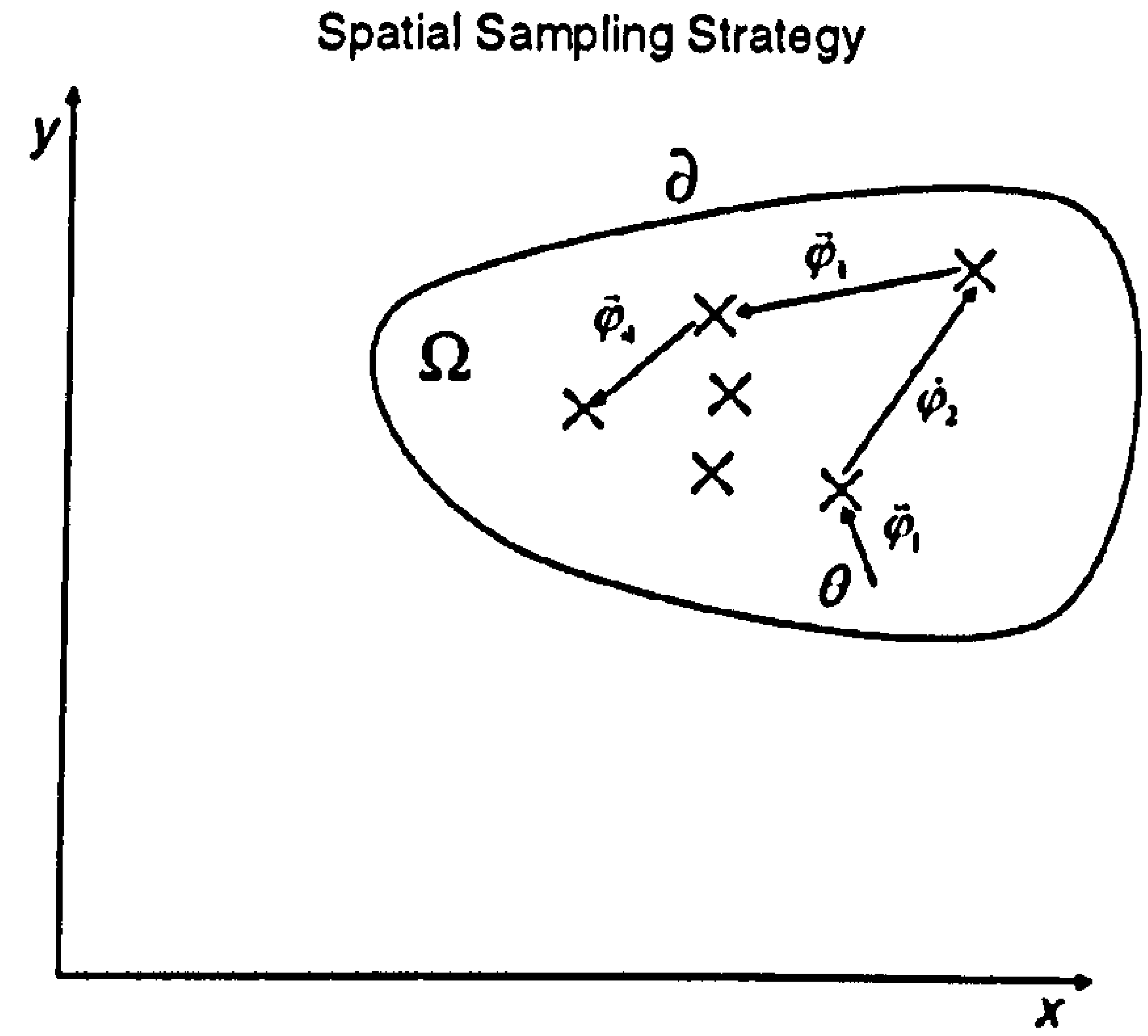

Figure 1 Schematic diagram of the spatial sampling strategy

The total error of the sample mean (Ψ) is a function of the sample size (the number of clusters n and the number of households within a cluster m) and the spatial sampling strategy $(\vec{\varphi}_1, \ldots, \vec{\varphi}_m)$ that selects the households in each cluster. An expression for Ψ can be obtained in terms of its arguments listed above, which implicitly include the design effect.[11,15-17]

Figure 1 shows schematically the spatial sampling strategy. In this figure, x and y are the coordinates in space, the symbol 'x' denote the location of a household, θ the starting point of the survey, $\vec{\varphi}_i$ the vector connecting two households $i-1$ and i to be visited sequentially (there are $m-1$ vectors connecting m households and one vector connecting the starting point of the survey to the first household to be surveyed), while Ω is the cluster and ∂ the boundary of the cluster.

The first constraint is an inequality constraint. It sets an upper limit α to the cost of the survey c. The cost of the survey is a function of n, m and the total distance covered by the surveyor (additional terms such as the number of vehicles used can also be included). The total distance covered is given by $\sum_{i=1}^{m}\delta(\vec{\varphi}_i)$ where $\delta(\vec{\varphi}_i)$ is the amplitude of vector $\vec{\varphi}_i$.

The second constraint is expressed as a set constraint. $(\vec{\varphi}_1, \ldots, \vec{\varphi}_m) \in Z$ means that the pathway should be an element of the set Z. Z models the distribution of the households within a cluster. For simplicity in this example, we assume that all clusters share the same spatial distribution of the households. This assumption could, however, be relaxed as context-specific optimization can be performed by specifying the associated spatial configuration of households. Alternatively, judgements about typical configurations and distributions of households can be made and stochastic models of household distributions used.

There are many mathematical methods available to solve complex optimization problems; the choice of the method depends on the formulation of the optimization problem. In the case of the above household survey sampling problem, the appropriate solution method will depend primarily on the models of the survey pathway and the spatial distribution of the households. The mathematical programming methods include function space methods,[18,19] integer-based methods,[20] and combinatorial methods.[21,22] These methods have been widely and successfully used in applications such as operations research, economics, management science, control engineering, and network design amongst many others.

As in the case of any approach, the use of mathematical programming has its advantages and disadvantages. On the one hand it could be argued that this approach presents a conceptually simplistic (albeit mathematically complex) formulation of the household sampling problem and paves the way for a robust and explicit formulation of the household survey sampling problem.

On the other hand, one of the disadvantages of the mathematical programming approach is that it requires analytical expressions of the performance measure and the constraints as functions of the control variables. These requirements could be viewed as a disadvantage, compared with the Monte Carlo approach,[3,4] because they entail understanding of the way in which the control variables influence performance measure and constraints. We would argue, however, that the advantages gained in using the mathematical programming approach far outweigh any disadvantages. The mathematical programming approach provides a rigorous means to optimize the sampling methods under different scenarios without the need of exhaustive Monte Carlo simulations to cater for all permutations of the setting.

Conclusion

Households sampling methods such as EPI have been widely and successfully used. These methods, however, suffer from a number of disadvantages. There is a need to develop alternative sampling methods in situations where traditional data collection methods prove challenging or unfeasible. We believe that although mathematical programming methods are not yet widely used in epidemiology, they have an important role to play in this area. One application is to optimize household survey sampling methods so that they become more reliable in circumstances where sampling frames are not available.

We have described the first step in a rigorous approach towards optimizing household survey sampling methods in settings where sample frames are not feasible. The sampling methods obtained through the optimization approach requires rigorous validation. Initial validation could be done using existing geo-referenced data but formal validation will require practical field testing.

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KEY MESSAGES

- Obtaining representative samples in household surveys is difficult to achieve in situations where detailed sampling frames are unavailable or are unreliable.
- Mathematical programming could be used to optimize EPI sampling as well as radically different methods appropriate for household survey sampling without sample frames.

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Optimisation of the T-square sampling method to estimate population sizes

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Optimisation of the T-square sampling method to estimate population sizes

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Abstract

Population size and density estimates are needed to plan resource requirements and plan health related interventions. Sampling frames are not always available necessitating surveys using non-standard household sampling methods. These surveys are time-consuming, difficult to validate, and their implementation could be optimised. Here, we discuss an example of an optimisation procedure for rapid population estimation using T-Square sampling which has been used recently to estimate population sizes in emergencies. A two-stage process was proposed to optimise the T-Square method wherein the first stage optimises the sample size and the second stage optimises the pathway connecting the sampling points. The proposed procedure yields an optimal solution if the distribution of households is described by a spatially homogeneous Poisson process and can be sub-optimal otherwise. This research provides the first step in exploring how optimisation techniques could be applied to survey designs thereby providing more timely and accurate information for planning interventions.

Background

There is a constant need to estimate population size and density for the purposes of planning resource requirements or assessing health needs. For reasons relating to timeliness, cost or practicality, data are often obtained through surveys that aim to collect representative samples. Public health specialists rely traditionally on detailed sample frames to survey populations. There are however many situations (such as those relating to displaced populations in emergencies) in which detailed sample frames are either unavailable or unfeasible. Only a small number of sampling methods are suitable for such situations.

Ecological methods, which often do not require a detailed sample frame, can offer practical solutions to household sampling problems and are currently being explored. These methods include sequential sampling techniques to estimate prevalence or program coverage [1, 2], capture-recapture techniques [3, 4], adaptive sampling [5], T-Square sampling [6] and Catana's wandering quarter method [7] to estimate population size and density.

One of the problems in validating and verifying sampling methods used in situations devoid of sampling frames is the difficulty in analysing the properties of the sampling methods [8]. Traditional optimisation of sampling methods is done using computationally intensive re-sampling techniques such as Monte Carlo (MC) or Latin Hypercube Sampling (LHS) simulations, while experimenting with different permutations of the parameters of the sampling method on simulated or real population data. Further, from a theoretical perspective, there are infinitely many scenarios (covering a wide distribution of household and individual data) for which the sampling method requires validation and verification.

Mathematical Programming (MP) provides a powerful tool to optimise rigorously the properties of sampling methods [8]. The key advantage of MP is that it provides a more directed and less computing-intensive approach for optimisation compared to traditional methods. The purpose of this paper is to demonstrate this methodology in practice. Optimisation of a sampling method through MP could be considered as the first step in a four-step procedure for validation as shown in figure 1. Here, we explore optimisation as a first step in developing an alternative sampling method using the T-Square sampling method to estimate human population sizes as an example.

T-Square sampling is a distance-based sampling method whose statistical properties have been thoroughly investigated [9-14]. It has been used in ecology to estimate sizes, densities and deviations from random spatial distributions of mainly plant populations [15] and more recently it has been used to estimate the size of displaced human populations in emergency situations [6, 16, 17].

Estimating human populations in emergencies by using distance-based methods, such as the T-Square, rely on collecting data on distances between households (shelters) rather than on households *per se*. Advantages of distance sampling methods include:

- Human population density can be estimated even when not every household per unit area is detected;
- The same population density estimate can be calculated from data independently collected by multiple observers;
- A relatively small number of distances need to be measured;
- It may be less resource intensive and potentially more accurate than traditional sampling methods such as the quadrant method [6, 16].

Two of the substantive issues to be addressed in this paper are whether:

- The assumptions on which the T-Square method is originally based for estimating plant population sizes are equally valid for estimating human population sizes;
- The T-Square method can be optimised.

Analysis

T-Square sampling and other distance-based methods

Two of the simplest distance-based methods to estimate population densities are those which measure distances between a random geographical point and its nearest household or a randomly selected household and its nearest neighbour. If the households are randomly distributed in the region of interest, both approaches are equivalent. On the other hand, if the households are aggregated, the assumption of randomness can be violated and both methods are prone to bias. However, the bias of the two methods in estimating population densities tends to be in opposite directions. This is because when households are aggregated, the average distance from a 'random geographic point to the nearest household' increases while the average distance measured between a 'random household to its nearest neighbour' decreases (figure 2). Using both distances together improves the robustness of the estimation method compared to the use of any estimation method which relies on either distance measure on its own.

The T-Square method starts with generating random geographical points in the region of interest (Ω) such as point S_1 in figure 3. From each point, the distance x is measured to the nearest household H_1 along the line C connecting S_1 and H_1. At H_1 the area is split, by a line Q which goes through H_1 and is perpendicular to line C, in two planes L and R. The distance y from H_1 to the nearest household in the opposite plain R (plain which does not contain point S_1) is measured. The "T" formed by lines C and Q gives the method its name. The calculation of the population size and population densities based on these distances is explained in detail in Appendix I. The T-Square method assumes "complete spatial randomness". In mathematical terms, this assumption means that the households are described by a spatially homogeneous Poisson process (Appendix I).

An alternative method to T-Square sampling is Catana's 'wandering quarter' method [7]. The principle of the method is illustrated in figure 4. A transect of random direction and a random starting point (S_1) is selected. From this point, the closest household (H_1) within a 90° vertex (area bounded by the dotted lines) is determined. Starting from this household, the next household (H_2) is selected in the same way resulting in a sequence of distances ($x_1, x_2, \ldots$). This process is continued until the nearest household is outside the survey area. Although the properties of this method have not been thoroughly studied as those of T-Square sampling, Catana's method does not require the assumption of complete spatial randomness [7, 13].

Choosing the appropriate distance-based method for use in human populations requires careful practical and theoretical considerations. Distances within which a surveyor can determine accurately the closest household from a random point or the closest household from a previously selected household are limited. In practice, it could be difficult to identify precisely the location of a household that occupies a large area. Furthermore some sampling methods are more sensitive than others to errors in the measurement of angles and distances. In the T-Square method the sample observations are pre-determined, unlike the wandering quarter method. The wandering quarter method could therefore be more difficult to plan in advance compared to the T-Square method if health data are to be collected from each household.

In addition to T-Square sampling and the Catana's wandering quarter methods, there are other distance-based methods such as the line-transect and point-transect distance methods [18, 19]. It could be argued that although these methods are well established for estimating abundance of biological populations (plants or animals), extrapolating their use to household surveys would require evaluation. We note however that distance-based methods do not replace classical sampling methods where sample frames are available.

Optimisation of the T-Square sampling method

The elements of optimising any household sampling method are the objective function (performance measure) to be optimised (maximised or minimised), the parameters of the method which can be tuned to optimise the objective function, and the constraints that are imposed on the values of these parameters [8]. In the context of optimising the T-Square method this is translated as follows.

The choice of the objective function to be optimised is not arbitrary and should be carefully considered. In real-life applications, a set of empirically-derived objective functions would be proposed and tailored to particular situations. Appendix II derives a simple objective function based on practical considerations. We present several examples of objective functions in the following paragraphs.

The simplest objective functions to be optimised (minimised in this case) are the standard error of the estimate of the average area per household (*E*) or the "cost" of the sampling (C), defined in a generic sense, as a measure of the "quantity of resources" required for sampling (for example, human resources). We can define an objective function which combines both those functions: $T = E + \alpha C$ where α is a trade-off scalar, or parameter, which has a dual purpose: to scale E and C numerically to the same unit and to weight the relative significance of each of them in terms of the overall performance measure.

An obvious parameter to tune is the number of sampling points (m). Both terms (*E* and *C*) in the above combined objective function depend on m. We would expect $E(m)$ to decrease monotonically with respect to m and $C(m)$ to increase monotonically with m thus providing a trade-off in the choice of m to be optimised.

A key assumption in the optimisation analysis is that the distribution of the households can be described adequately by a two-dimensional spatially homogeneous Poisson process (Appendix I). In using the T-Square method, there is a potential bias in the estimate of the household density (mean number of households per unit area) if the Poisson assumption does not hold. The standard error term $E(m)$ is proportional to $\sqrt{m^{-1}}$ provided the sampling points are well spaced. The constant of proportionality however will depend on the underlying distribution and therefore would influence the optimal solution. Unlike the expression for $E(m)$, the expression of $C(m)$ is derived from practical considerations. The constraints on m are usually in the form of simple bounds on the sample size, i.e. greater than zero, but less than 60.

For illustrative purposes, we chose the following objective function to be minimised as a first example:

$$T(m) = \sqrt{m^{-1}} + \alpha m^2 \qquad (1)$$

The above objective function is the weighted sum of two terms: the standard error of the population size estimate and a quadratic cost relationship. The optimal sample size is sensitive to the choice of the trade-off parameter α. The choice of α balances the importance of maximising the precision of the estimate against minimising cost. In this example, we set α to 10^{-5} and the simple bound constraint to $1 \le m$. Figure 5 shows the variation of $T(m)$ with m.

The minimisation was carried out in *Mathematica* using a standard non-linear programming optimisation algorithm [20]. The optimal sample size (to the nearest integer) is $m^* = 58$.

Another example of an objective function was chosen to reflect a different cost-sample size relationship:

$$T(m) = \sqrt{m^{-1}} + \alpha \tanh(\beta m) \qquad (2)$$

The standard error term is the same as in the previous example, but the cost term is assumed to increase asymptotically with respect to sample size and is modelled using a hyperbolic tangent function where β is an empirically derived parameter. In the simulation, β is set to 0.002. This relationship represents scenarios where the incremental cost becomes smaller with progressively increasing sample size. The trade-off parameter α was set to unity and the same constraint was used as before. Figure 6 shows the variation of $T(m)$ with m. The optimal sample size (to the nearest integer) in this example is $m^* = 40$.

The two previous simulations were concerned with optimising sample size. Once the optimal sample size is determined, one can envisage a second optimisation stage whose aim is to select the optimal pathway for data collection. This could be required in practice for operational reasons and is not necessarily reflected in the cost function of the first stage optimisation problem. The optimal pathway is defined as the shortest pathway connecting all the sampling points. It is assumed here that one observer would be carrying out the survey.

Assume that the optimal sample size (obtained in the first optimisation step) is $m^* = 50$. Figure 7 simulates a two-dimensional display of the 50 sampling points chosen randomly in a square plane whose boundary corner points have coordinates: (0,0), (0,5), (5,0) and (5,5). The two coordinates of each of the sampling points are generated independently using a pseudo random number generator. The random number generator produces a real number uniformly distributed between 0 and 5. Ignoring for the time being the straight-line segments, the dots numbered 1 to 50 in figure 7 represent the locations of the random points in the plane. Dot 1 is the location of the first sampling point selected, and dot 50 is the location of the last point selected.

The optimisation is concerned with computing the shortest pathway that connects all the sampling points. This is a very well known and classical problem in combinatorial optimization known as the "Travelling Salesperson Problem" [21]. The problem is to determine the least-distance route taken by a salesperson to visit a fixed number of cities in which each city is visited once only and in which the trip starts and ends at the same point. The Travelling Salesperson Problem (TSP) is not easy to solve (computational difficulty increases with the number of cities) and there is extensive literature on fast and efficient numerical algorithms used to solve both the classical version and more complex variations of the TSP [22, 23].

Here, we solved the TSP problem in *Mathematica* [20, 24]. The optimisation method used is called simulated annealing. Simulated annealing is a stochastic approach to find the global solution of an optimization problem where there could be multiple local solutions [25]. In this approach, an optimal solution is found iteratively by selecting randomly at each step a point in the neighbourhood of the current solution and then directing the search in the subsequent steps to improve the value of the objective function whilst not getting trapped in a local solution. It has been found that simulated annealing has several advantages over other optimization methods to solve TSP [26]. (Additional information and an illustration of simulated annealing [27]).

Figure 8 is a schematic diagram of a plausible sequence of steps to apply the optimised T-Square in practice. This is an extension of the chronology of steps proposed by Grais *et al* [6]. The first step defines the elements of the first optimisation problem, namely the standard error of the average area per household, the cost-sample size relationship and the constraints on the sample size. The second step solves for the optimal sample size. The third step generates the random coordinates of the sampling points bounded by the perimeter of domain Ω (the region of interest). The fourth step defines the optimal pathway. Starting from any sampling point on the optimal pathway and moving in either direction (clockwise or counter clockwise) the fifth step collates the pair of distances comprising: (i) The distance from the random sampling point to the nearest household and; (ii) The distance from that household to its nearest neighbour on the other side of the T-Square. The sixth step applies the T-Square statistics to test the null hypothesis that distribution of the households is completely random (Appendix I). If the null hypothesis is statistically not significant, the optimisation procedure yields a sub-optimal solution. Note that that the optimisation in *Step* 2 is done only once whereas the optimisation is *Step* 4 is required for each set of sampling points.

Because of the strict condition of complete randomness demanded by the T-Square sampling method, it is unlikely that this method would always be applicable. Catana's method could prove a valid alternative in the sense that it does not require complete spatial randomness however no results have been published for its use in human populations. As in the case of the T-Square method, the Catana's method also has some restrictions in practice as discussed previously.

Conclusion

The purpose of this paper was to illustrate the principle of optimising a household sampling method in situations where sampling frames are unavailable. We chose the T-Square method as the exemplar because it holds promise for estimating population sizes in such situations. The optimisation of the T-Square method was demonstrated using a simple illustrative example depicting scenarios that are faithful to the basic assumption of the method, namely that the distribution of the households can be described by a two-dimensional homogeneous Poisson process. If this assumption does not hold, then the proposed optimisation procedure would likely be sub-optimal. Further work should investigate optimising the T-Square method in scenarios that are more realistic and situations in which the distribution of the households is not described by a spatially inhomogeneous Poisson process.

The rigorous optimisation approach, which was demonstrated here on the T-Square method, can be applied to any other sampling method. Traditionally sampling methods were validated using computer simulations and were not formally optimised. The scope of the traditional computing-intensive approaches are somehow limited and the necessity of a mathematical approach for validation and optimisation is warranted [8].

Optimisation of sampling methods provides important information for surveys in contexts where sampling frames are not available. These techniques may be contained within computer software used by field survey teams without requiring technical knowledge of the algorithm. That is, a user-interface allowing survey teams to enter their objective function and generate an optimal survey strategy can mask formulae making them easier for use by non-technical survey teams. Instead of asking survey teams to define the objective function, they could be led through a set of heuristics which provide the number of points to be sampled. For example, in the case of the T-Square method, if the distribution of dwellings is uniform (e.g. as in a street-structured refugee camp) then sample m_1 points, if the distribution of dwellings is clumped (e.g. as in a village-structured refugee camp) then sample m_2 points. Another way to envision this step would be to ask a similar set of heuristics which are then translated into an objective function behind the user-interface. The second stage of optimisation, the travelling salesperson problem, could be contained within computer software and adapted for use in the field. These heuristics could be tailored to the key issues at hand in other sampling methods.

Authors' contributions

KB and ZC conceived the study. All authors participated in drafting the manuscript. All authors read and approved the final manuscript.

Competing interests

All authors declare they have no competing interests.

Appendix I. Statistical properties of the T-Square sampling method

The T-Square sampling method can be described simply in figure 3. We assume that individuals live in households that are not enumerated (i.e. there is no sampling frame). In emergencies, impromptu shelters grouped haphazardly represent households. Points H_1,H_2 and H_3 represent the locations of three of the households. The region of interest (Ω) could contain n households ($H_1 \ldots H_n$). Point S_1 represents an *arbitrary* chosen point in Ω. It represents one sample of *m* points ($S_1 \ldots S_m$), which are generated randomly and used as anchors for the estimation method.

Recall the description of figure 3. *C* is the straight line joining S_1 to the nearest household (H_1). *Q* is the line perpendicular to *C* at household H_1. *Q* partitions the Ω plane into two semi-planes *R* and *L* indicated by the arrows. Household H_2 is the nearest to H_1 on the *R* semi-plane. The distance between S_1 and H_1, and the distance between H_1 and H_2 are denoted by x and y, respectively.

The primary assumption of the T-Square method is that the objects of interest (plants or households) are distributed randomly within the region of interest which means that their spatial distribution is described by a two-dimensional homogeneous Poisson point process [11, 12]. This means that for any two non-overlapping regions A and B (within Ω) of areas δ_A and δ_B respectively, the probabilities of finding k households in A and B are statistically independent and that each probability is proportional to the area size:

$$p(N_{\mathrm{A}}=k)=\frac{\exp(-\lambda\delta_{\mathrm{A}})\times(\lambda\delta_{\mathrm{A}})^{k}}{k!}$$
$$p(N_{\mathrm{B}}=k)=\frac{\exp(-\lambda\,\delta_{\mathrm{B}})\times(\lambda\delta_{\mathrm{B}})^{k}}{k!} \qquad \text{(I.1)}$$

In Equation (I.1), N_{A} and N_{B} are respectively the number of households in regions A and B, and λ is the density (number of households per unit area) of the underpinning Poisson process and the parameter to be estimated.

Of course, the principal assumption of the T-Square method is very restrictive in the context of human population estimates. There are several statistical tests available to test for complete randomness of spatial point patterns [9, 12-14, 28-31]. The relaxation of this assumption has implications for the robustness of the method (see below) used to estimate λ [12].

Recall that x is the distance between point S_1 and household H_1. Consider next the ensemble of all such distances between the randomly chosen sample points ($S_1 \ldots S_m$) and their nearest households ($H_1 \ldots H_n$) and assume for simplicity that $n=m$. The probability density function (*pdf*) of x is [9, 31]

$$f(x)=2\pi\lambda x\exp\left(-\pi\lambda x^{2}\right) \qquad \text{(I.2)}$$

It follows from Equation (I.2) that the random variable ω defined by $\omega = 2\pi\lambda x^2$ is chi-square (χ^2) distributed with 2 degrees of freedom [12].

If we selected the households arbitrarily, instead of the sampling points, and measured the distance between each selected household and its nearest neighbour, this distance will have the same *pdf* as x. However, households cannot be selected arbitrarily without enumeration of these households.

Distance methods invariably use pairs of distances between each of the random points and the nearest household and the distances between those households and their nearest neighbours (defined in some sense). With reference to figure 3, this means that the pair (x, y) could be used to estimate λ. Besag and Gleaves [9, 12] showed that under the principal assumption that the households are distributed as a homogeneous Poisson process, $\frac{y}{\sqrt{2}}$ is independent of x and identically distributed to it. In other words, $\frac{y}{\sqrt{2}}$ has the same *pdf* as x (Equation I.2). Using this statistical feature of the distribution of the pair of variables (x, y), a robust estimator for λ is [12]

$$\eta = \pi \times \frac{\left(\sum_{i=1}^{m} x_i^2 + \frac{1}{2}\sum_{i=1}^{m} y_i^2\right)}{2m} \qquad \text{(I.3)}$$

$$\lambda = \eta^{-1}$$

where η is the average area per household.

The principal assumption can be tested using appropriate T-Square sampling statistical tests [9, 11, 14]. These statistical tests are used to test the null hypothesis that the households (or shelters) are distributed as a homogeneous two-dimensional Poisson process. Under the null hypothesis the random variable on the left hand side of Equation (I.4) [6, 9, 11]

$$z = \frac{\left(t - \frac{1}{2}\right)}{\sqrt{(12m)^{-1}}} \tag{I.4}$$

is normally distributed with zero mean and unit variance, where

$$t = \frac{\sum_{i=1}^{m} \left(\frac{x_i^2}{x_i^2 + \frac{1}{2} y_i^2} \right)}{m} \tag{I.5}$$

As was argued by Diggle [12] and proposed in practice for use in human population estimates by Grais *et al* [6], hypothesis testing can be carried out as a two-step procedure. In the first step, the above null hypothesis is tested for statistical significance and if found to be statistically not significant, a supplementary null hypothesis is tested for statistical significance. In this second step, the null hypothesis corresponds to u^2 being χ^2- distributed with $m-1$ degrees of freedom where

$$u = \frac{48m}{13m+1} \times \left(m\, Log\left(\sum_{i=1}^{m} \left(x_i^2 + \frac{1}{2} y_i^2 \right) \right) - \sum_{i=1}^{m} Log\left(x_i^2 + \frac{1}{2} y_i^2 \right) \right) \quad (I.6)$$

If both hypotheses are statistically not significant (when the spatial pattern is described by a two-dimensional homogeneous Poisson process), it is justified to use Equation (I.3) to estimate the average area per household (η). The 95% confidence interval for η is calculated by:

$$I = \left[\eta - 1.96 \times \frac{\eta}{\sqrt{2m}}, \eta + 1.96 \times \frac{\eta}{\sqrt{2m}} \right] \quad (I.7)$$

The implication is that the underlying assumptions concerning the distributions of the households (or shelters) may be violated as indicated by the statistical tests performed after field data were collected. In this case, a more robust estimate of η is [12, 13]

$$\eta = \frac{\pi}{m} \times \sqrt{\left(\sum_{i=1}^{m} x_i^2 \times \frac{1}{2} \sum_{i=1}^{m} y_i^2 \right)} \quad (I.8)$$

Equation (I.3) (or Equation (I.8)) estimates the average area per household. The human population ρ in the region of interest (Ω) can be estimated by Equation (I.9) [6]

$$\rho = \kappa \times \frac{\Gamma}{\eta} \quad (I.9)$$

where κ is the average household population and Γ is total the area of region Ω.

Appendix II. Objective function

This section describes a simple objective function which has been used in practice to determine sample size requirements in cluster surveys on provision of water, sanitation and hygiene. The cluster surveys used a two stage sampling approach. In the first stage the primary sampling units (PSUs) were selected with a probability proportioned to their size. In the second stage a simple random sample of size *b* was taken from each PSU, where *b* is the number of basic sampling units (BSUs) within each PSU. *b* is also known as the 'take'.

The objective function describes the relationship between the survey cost and number of BSUs. The total sample size (*s*) is determined by the number of clusters (*c*) and the number of BSUs ($s = c \times b$). The cost of the total survey (C_{survey}) is the sum of a fixed cost (C_{fixed}) independent of *b* and a variable cost ($C_{variable}$) which depends on *b* and *c*.

$$C_{survey} = C_{fixed} + C_{variable} \tag{II.1}$$

The variable cost is given

$$C_{variable} = c \times C_{PSU} + c \times b \times C_{BSU} \tag{II.2}$$

where C_{PSU} and C_{BSU} are respectively the survey cost per PSU and per BSU.

If we set $C_{ratio} = \frac{C_{PSU}}{C_{BSU}}$ and assume without loss of generality that $C_{BSU} = 1$ (i.e. represent all costs relative to C_{BSU}), Equation (II.2) becomes

$$C_{variable} = (C_{ratio} + b) \times c \tag{II.3}$$

The required size of the cluster can be expressed in terms of the expected proportion of the target population, *p*, and the standard error of its mean estimate, ξ [32]

$$c = \frac{p \times (1-p)}{\xi^2 \times b} \times d_{eff} \tag{II.4}$$

where d_{eff} is the design effect [33]

$$d_{eff} = 1 + \rho \times (b-1) \tag{II.5}$$

ρ is the rate of homogeneity. Substituting Equations (II.4) and (II.5) in (II.3) gives the expression of $C_{variable}$ in terms of *b*

$$C_{variable} = (C_{ratio} + b) \times \frac{p \times (1-p) \times (1 + \rho \times (b-1))}{\xi^2 \times b} \tag{II.6}$$

Figure 9 shows $\frac{C_{survey}}{C_{BSU}}$ in terms of *b*.

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Figure legends

Figure 1. Validation steps of a household survey sampling method.

Figure 2. A schematic of distance-sampling methods. (Abbreviations: H, household; S, sampling points)..

Figure 3. T-Square sampling method. (Abbreviations: H, household; S, sampling points; distances labelled x and y; planes labelled L and R; lines labelled Q and C; Ω, region of interest).

Figure 4. Catana's wandering quarter sampling method (Abbreviations: H, household; S, sampling points; x, distance).

Figure 5. Objective function corresponding to Equation (1). (Abbreviations: T, objective function; m, number of sampling points).

Figure 6. Objective function corresponding to Equation (2). (Abbreviations: T, objective function; m, number of sampling points).

Figure 7. Location of sampling points.

Figure 8. An illustration of the steps followed when applying the T-Square method in practice.

Figure 9. An example of a practically constructed objective function.

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Methods for health surveys in difficult settings: charting progress, moving forward

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Methods for health surveys in difficult settings: charting progress, moving forward

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Abstract

Health surveys are a very important component of the epidemiology toolbox, and play a critical role in gauging population health, especially in developing countries. Research on health survey methods, however, is sparse. In particular, current sampling methods are not well adapted for certain 'difficult' settings, such as emergencies, remote regions without easily available sampling frames, hidden and vulnerable population groups, urban slums and populations living under strong political pressure. This special issue of *Emerging Themes in Epidemiology* is entirely devoted to survey methods in such settings, and builds upon a successful conference in London highlighting problems with current approaches and possible ways forward. Greater investment in research on health survey methods is needed and will have beneficial effects for populations in need.

Editorial

Health surveys are the stethoscope, thermometer and pressure gauge of global health. Measurement of the health-based Millennium Development Goals depends on large-scale surveys such as the Demographic and Health Surveys, Multiple Indicator Cluster Surveys, and Living Standard Measurement Surveys [1]. For most international health interventions, including preventive disease control, curative care, health system strengthening, and emergency relief, population surveys are necessary to monitor implementation. Surveys can also provide direct measures of health outcomes and impact at the population level, and highlight important differentials in exposures and/or disease risk within particular groups, thus providing a trigger for action.

Despite the contribution that survey data can make to global health improvement, research to develop survey methods in difficult settings has largely stagnated over the past two decades. A mere handful of studies on this topic have been published. This may be because of a perception that surveys do not require the same sophistication and rigour as other types of studies, such as clinical trials. Yet surveys present a number of technical challenges, including the need to select representative samples, achieve adequate statistical precision and minimise bias in data collection. In resource-rich, industrialised settings, the surveyor's task is mostly straightforward: here, situations are often stable; communities are administratively organised; people are largely familiar with the use of surveys; transport and logistics are not problematic; capacity for data collection and analysis is high; legal and socio-economic conditions tend to protect participants against the untoward effects of research; and, crucially, comprehensive, stable population lists are more readily available, allowing researchers to select a representative random sample, the gold standard of survey sampling. Furthermore, the existence of sophisticated health information systems relying on prospective surveillance, and the high utilisation of health services, often remove much of the need for surveys, at least as a tool for monitoring service coverage and health outcomes.

There are, however, many settings throughout the world where these conditions are not met and where the problems of imprecision and bias are compounded by formidable logistical challenges, as well as serious political, security, cultural or ethical constraints. A list of such "difficult" settings might include: humanitarian crises resulting from conflict and natural disasters; poor and/or remote developing country settings where survey design options are constrained by insufficient census or geographic data; "hidden" and/or vulnerable populations (such as sex workers, orphans, street children, victims of sexual and gender-based violence, undocumented migrants, nomadic communities, and women as a whole in some cultures); urban and peri-urban slums and other marginalised areas in developing country cities; and populations under strong political pressure, among whom data collection may be actively discouraged by authorities and/or entail considerable risks for beneficiaries and researchers. Paradoxically, it is precisely in these settings that surveillance data are most lacking, and surveys most badly needed to generate information about population health.

On 15 February 2006, the London School of Hygiene and Tropical Medicine (LSHTM) hosted its first international conference on health survey methodology in difficult settings [2]. The conference was attended by 125 participants from 31 institutions, including academic centres from Europe, United States of America and Australia, international non-governmental organisations (NGOs), United Nations agencies, and major public health institutions.

This special issue of *Emerging Themes in Epidemiology* is an outcome of the conference and has been developed with support from LSHTM and the Centre for Research on the Epidemiology of Disasters (CRED), Université Catholique de Louvain, Belgium. It represents a move to rekindle international interest in methodological aspects of health surveys. The issue showcases recent survey-related work in a variety of health-related fields, and encourages inter-disciplinary sharing of experience in an Open Access internet publication format.

Several contributions to this issue come from the humanitarian relief community. Over the past 30 years, surveys have been increasingly used for assessing, monitoring and guiding emergency operations in settings affected by conflict and natural disasters. In these settings, uncertain and rapidly-changing sampling frames are common, working conditions are challenging, data collection is not considered a priority, and political sensitivities abound. In his opinion piece, Spiegel [3] considers the role of various humanitarian stakeholders (NGOs, United Nations agencies, and academic centres) in the implementation of surveys in such conditions, and offers recommendations for how to improve existing practices through standardisation of methodologies, better training for field staff, timely deployment of skilled epidemiologists, and inter-agency peer review. Degomme and Guha-Sapir [4], from CRED, reflect on the creation of a database of surveys conducted in emergencies, and explore it to describe and interpret recent global trends.

Prudhon and Spiegel [5] review the validity of more than 350 mortality, nutrition and vaccination coverage surveys conducted during the last decade. This review both updates and improves upon previous work on nutritional [6] and HIV serological and behavioural surveys (Paul Spiegel, unpublished data), offering a much-needed reality check on the quality of survey work. No health topic is as fundamental as mortality and, in crises, its measurement is of crucial importance for both operational planning and advocacy. Moreover, as shown by recent work in Darfur [7] and Iraq [8], such surveys can be politically as well as methodologically controversial. Although manuals and guidance exist, survey methods used to estimate mortality retrospectively are only partially validated, and a number of methodological questions remain outstanding. The Working Group for Mortality Estimation in Emergencies [9] highlights several of these and suggests a set of best practice procedures.

These first four papers could not be more timely given the current drive to establish a global system to track the evolution of major crises through the systematic implementation of mortality and nutrition surveys [10]. The bottom line is that, while the quality of humanitarian surveys is improving, progress is slow and demand for data considerably outstrips present capacity. As a start, where guidelines exist, they should be adhered to more rigorously and adequate resources must be set aside to allow for sound data collection.

There are nonetheless many situations for which existing data collection methods do not offer feasible solutions and these often concern the most vulnerable and deprived populations. Approaches to deal with the lack of adequate sampling frames are painfully limited and have advanced little in the past decades. Traditionally, the main solution has been cluster sampling, whereby a representative number of starting points is selected within the target population based on probability proportional to size. Individuals or households around these points are then included using a variety of sampling methods. The standard 30x7 and 30x30 cluster designs, with household selection performed according to the Expanded Programme on Immunisation (EPI) method (perhaps more familiar to readers as "spin-the-pen" [11]), has been adopted widely, usually without sufficient appreciation of its limitations. This formulaic approach often leads to neglect of appropriate sample size calculation (i.e. considering the optimal number of clusters and households) and insufficient recognition of the need to plan for the effect of clustering (i.e. the design effect) and account for this in the analysis.

Despite its popularity, the EPI method is fraught with potential selection biases (such as favouring denser areas and households around the starting point) [12] and can be particularly difficult to conduct in urban and peri-urban settings. This is clearly a major area where alternative approaches need to be developed urgently. Grais et al.'s report from Niger [13] offers promising improvements to the "spin-the-pen" selection of households in urban areas. Bostoen et al.[14] take a more fundamental approach, and explore the use of mathematical programming as a tool for optimising household sampling designs. They use the example of population estimation, a key prerequisite for meaningful health planning in any setting without reliable census data. Making these alternative techniques user-friendly, and widely disseminating the skills for their application in the field should be a priority.

The concluding papers in our issue exemplify forward-thinking approaches to survey design and implementation, of the kind that we hope will increasingly inform health research in developing countries. Vallée et al. [15], working in Lao People's Democratic Republic, question the inevitability of cluster sampling based on probability proportional to population size, especially when the goal is to explore geographic determinants of health. Instead, they propose a purposeful selection of clusters guided by knowledge of the spatial arrangement of key population characteristics. Shirima et al. [16] describe their experience with personal digital assistants in a large, multi-indicator baseline survey in rural Tanzania and show that the use of advanced technologies can greatly simplify and facilitate the work of survey teams. Unfortunately, these devices still remain beyond the reach of many organisations, and require advanced expertise not often available on the ground. Nonetheless, they are a promising tool for data management in the future. Finally, Hargreaves et al. [17] report on a study from rural South Africa that compared standard survey approaches to a participatory ranking exercise as methods for rapidly estimating household wealth, a key determinant of health status. Although their results are not definitive, this study is a fitting conclusion to our issue, as it suggests that traditional survey methods need not always be put forward as a default solution. Innovative tools that partly incorporate participative and qualitative elements may be more appropriate in some settings.

Taken together, this collection of papers is a small but important leap towards greater investment in health survey methodology in settings where it is most needed. Following the success of the first conference in 2006, CRED and LSHTM will be co-hosting a second conference, to be held in Brussels on 4-5 June 2007 [18]. Much remains to be done, however. There is, in particular, much scope for the development of innovative approaches through collaboration with other disciplines, such as ecology, that have expertise in survey methodologies. Such inter-disciplinary collaboration should aim to convert potential methods into practical field tools, including reference and training materials for implementing agencies. Moving this agenda forward will undoubtedly require greater funding for both academic and operational research. Advocacy is needed to champion these activities among donors, governments and public health practitioners. While better survey data are crucial for governments, relief agencies and donors, they must ultimately serve to benefit the affected populations. Decision-making based on imprecise and biased data generated by insufficiently funded and skilled data collectors risks jeopardising health improvements. If there is an international obligation to equitably provide health to human beings, and if robust data are indispensable for health planning, then it is clear that provision of health services to many populations is being hindered by the use of sub-optimal survey techniques. Greater investment in the development of survey methods, both financially and intellectually, is urgently needed if major organisations are to target, monitor and evaluate their programmes more effectively.

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The authors declare that they have no competing interests.

Authors' contributions

All authors were part of the editorial committee for the special issue of *ETE* on health survey methods in difficult settings, and contributed to the writing of this editorial. K Bostoen and F Checchi co-wrote the first draft of this editorial, and, along with C Tam, coordinated work on the special issue. All authors read and approved the final manuscript.

Acknowledgements

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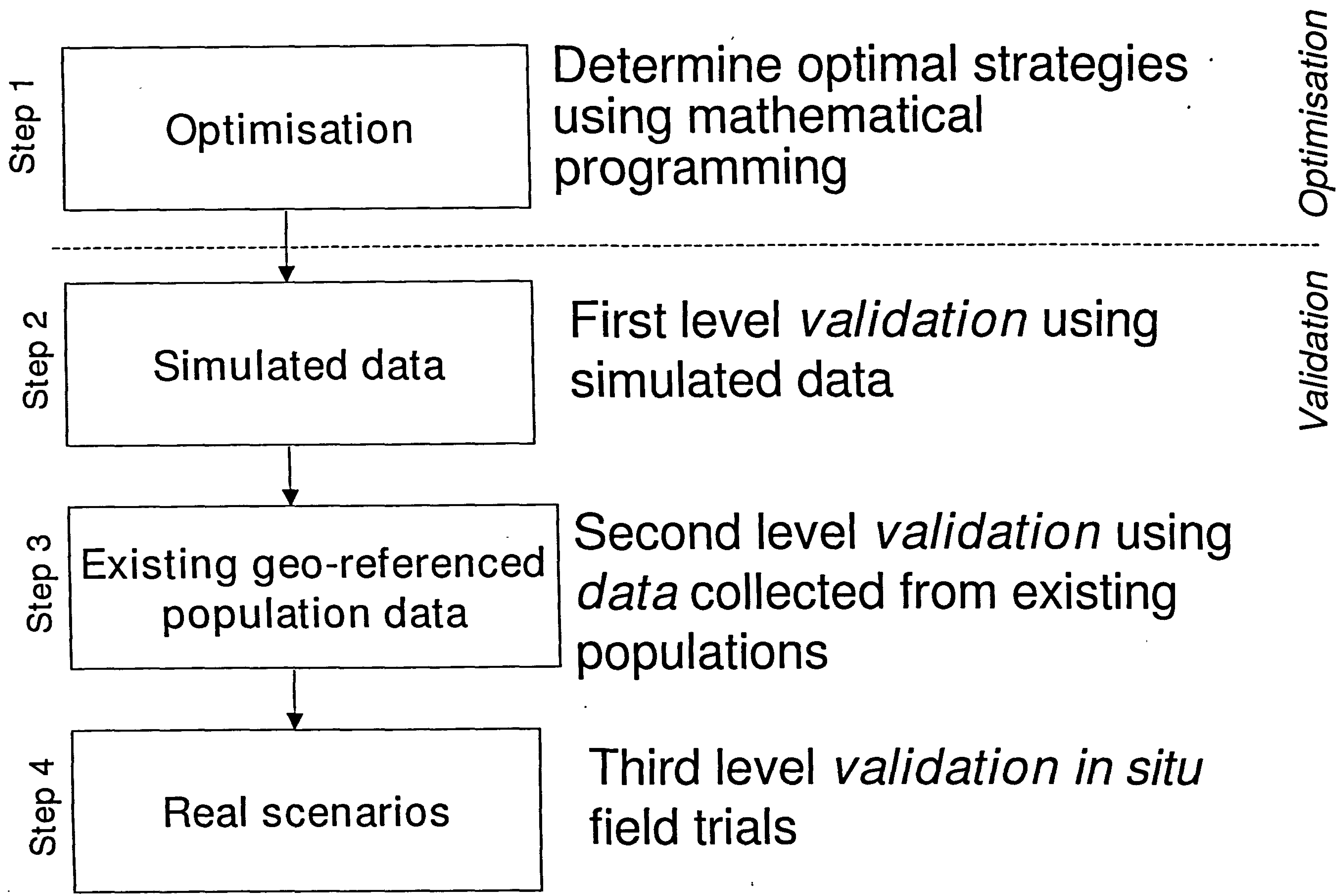
THE SPINE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Optimisation
Determine optimal strategies using mathematical programming
Optimisation
Step 2
Simulated data
First level validation using simulated data
Validation
Step 3
Existing geo-referenced population data
Second level validation using data collected from existing populations
Step 4
Real scenarios
Third level validation in situ field trials

Figure 1

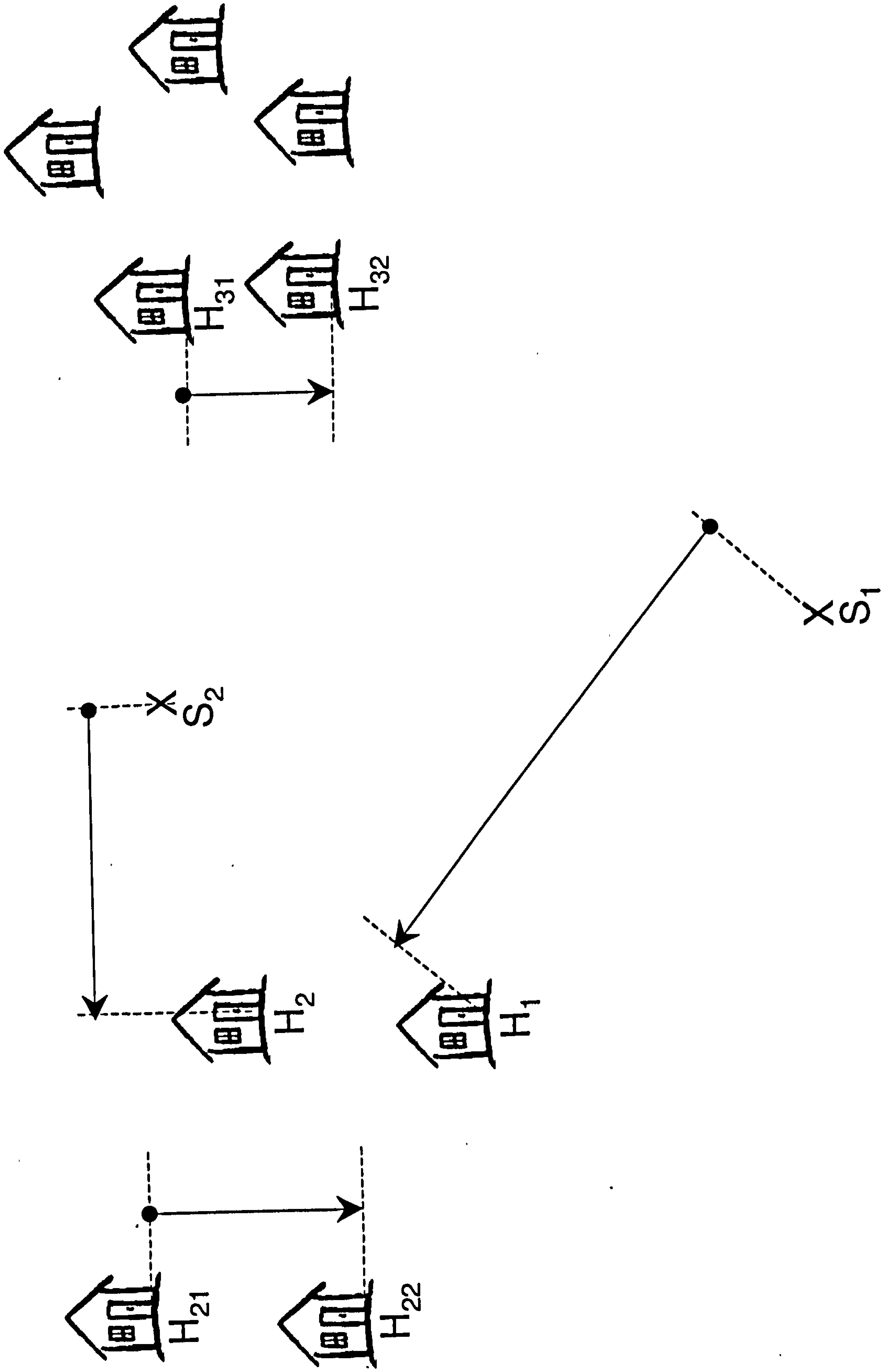
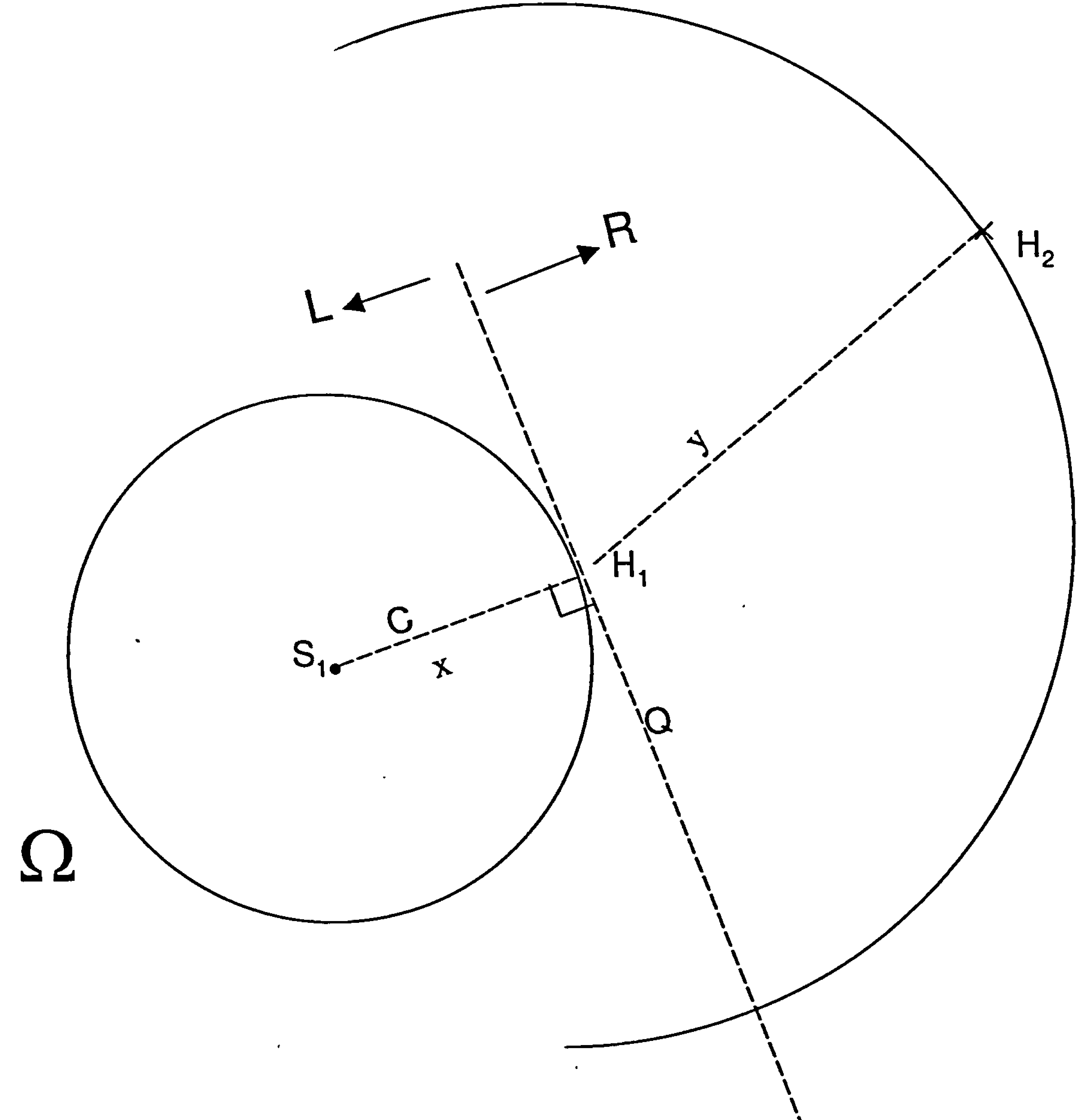


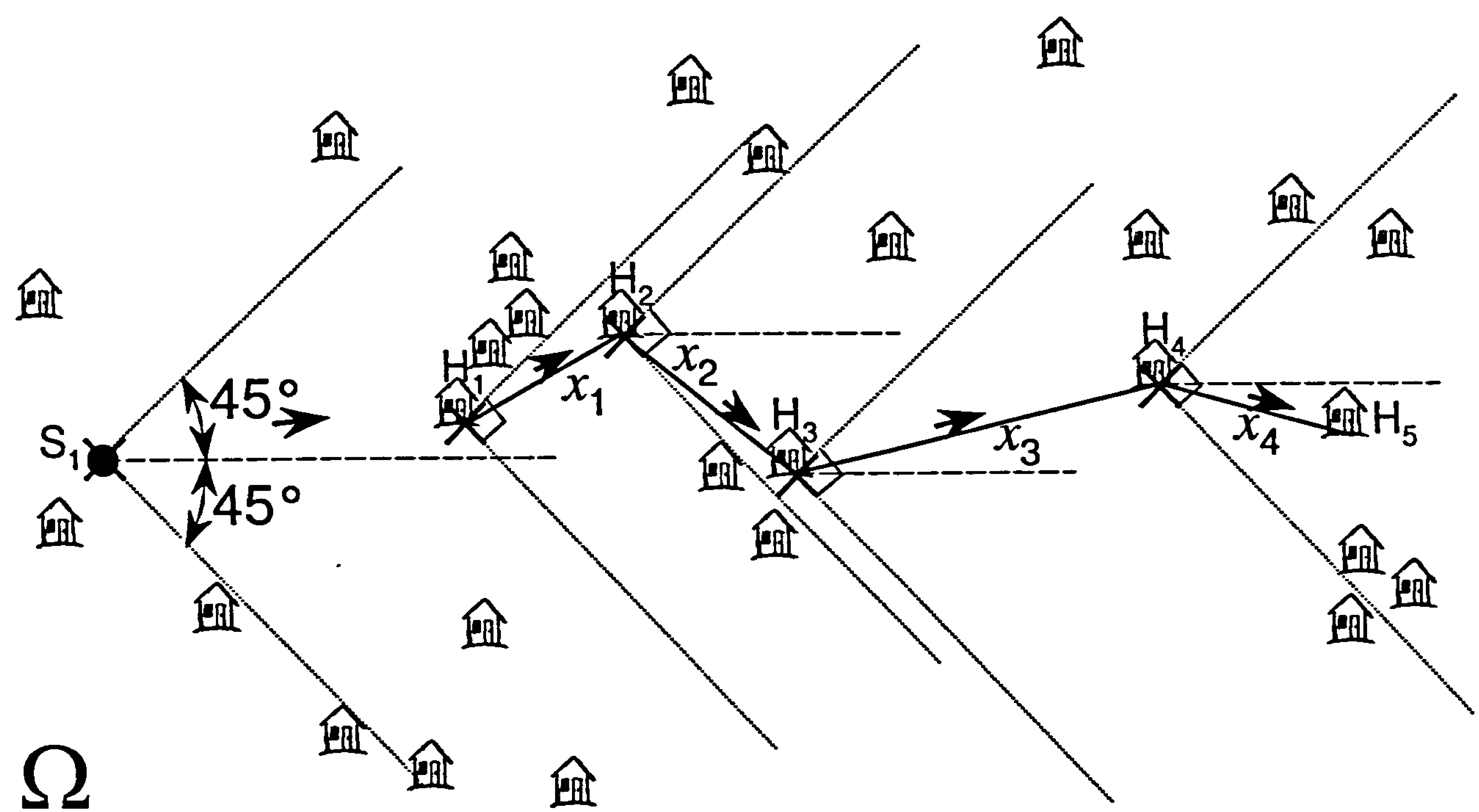
Figure 2

Figure 3



Adapted from Diggle (1979) [12] and Diggle (2003) [13]

Figure 4



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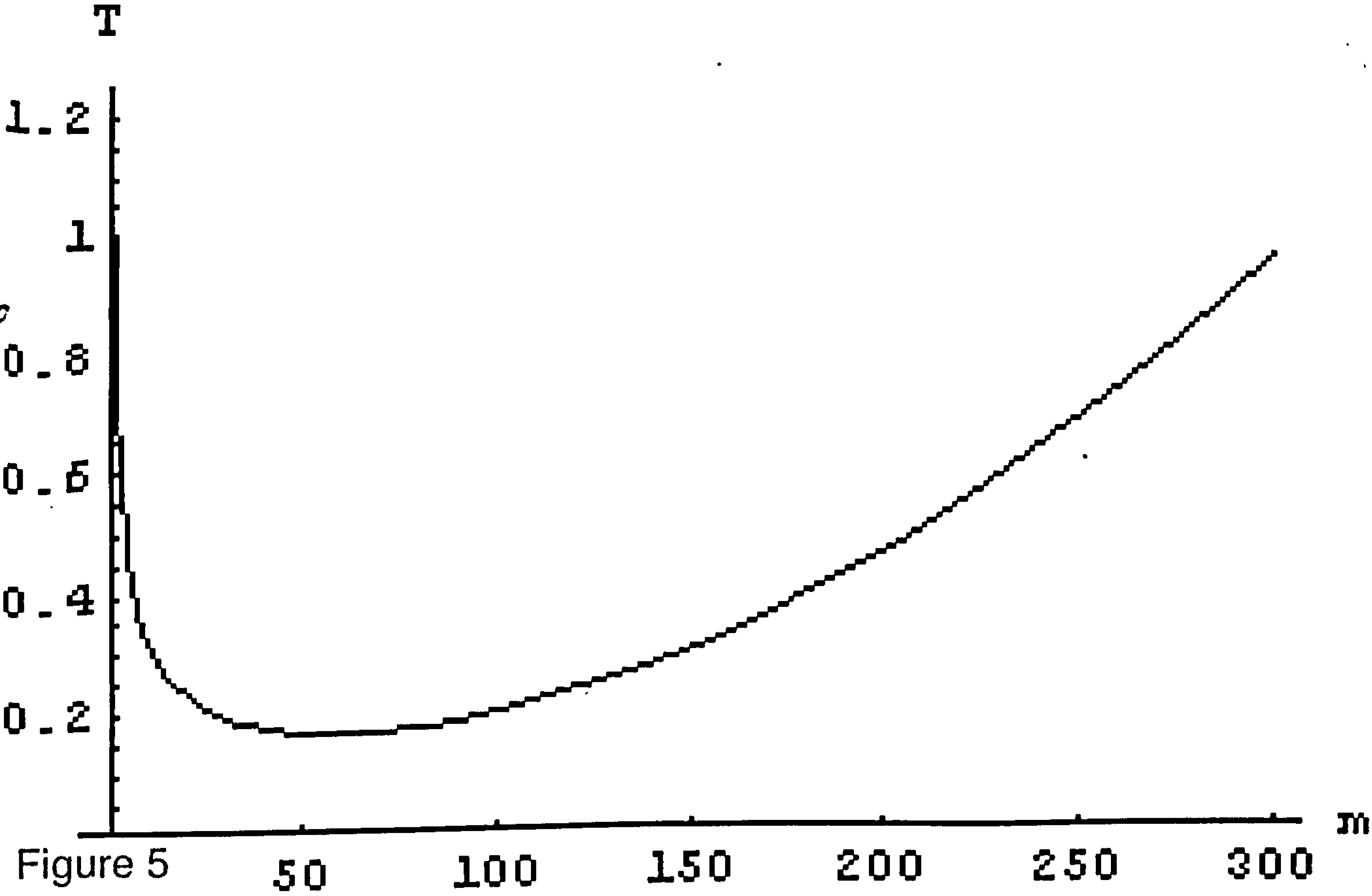
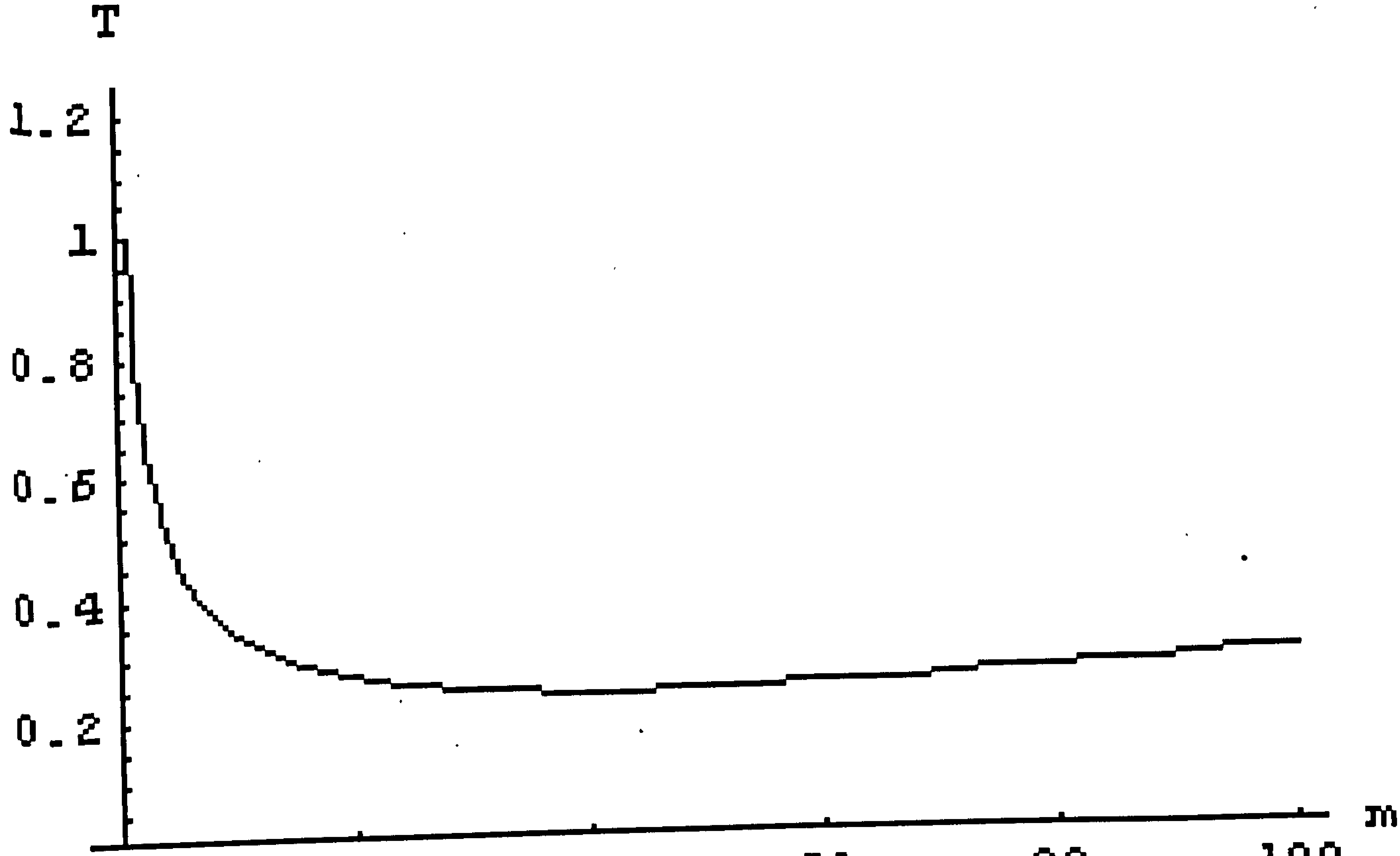


Figure 5



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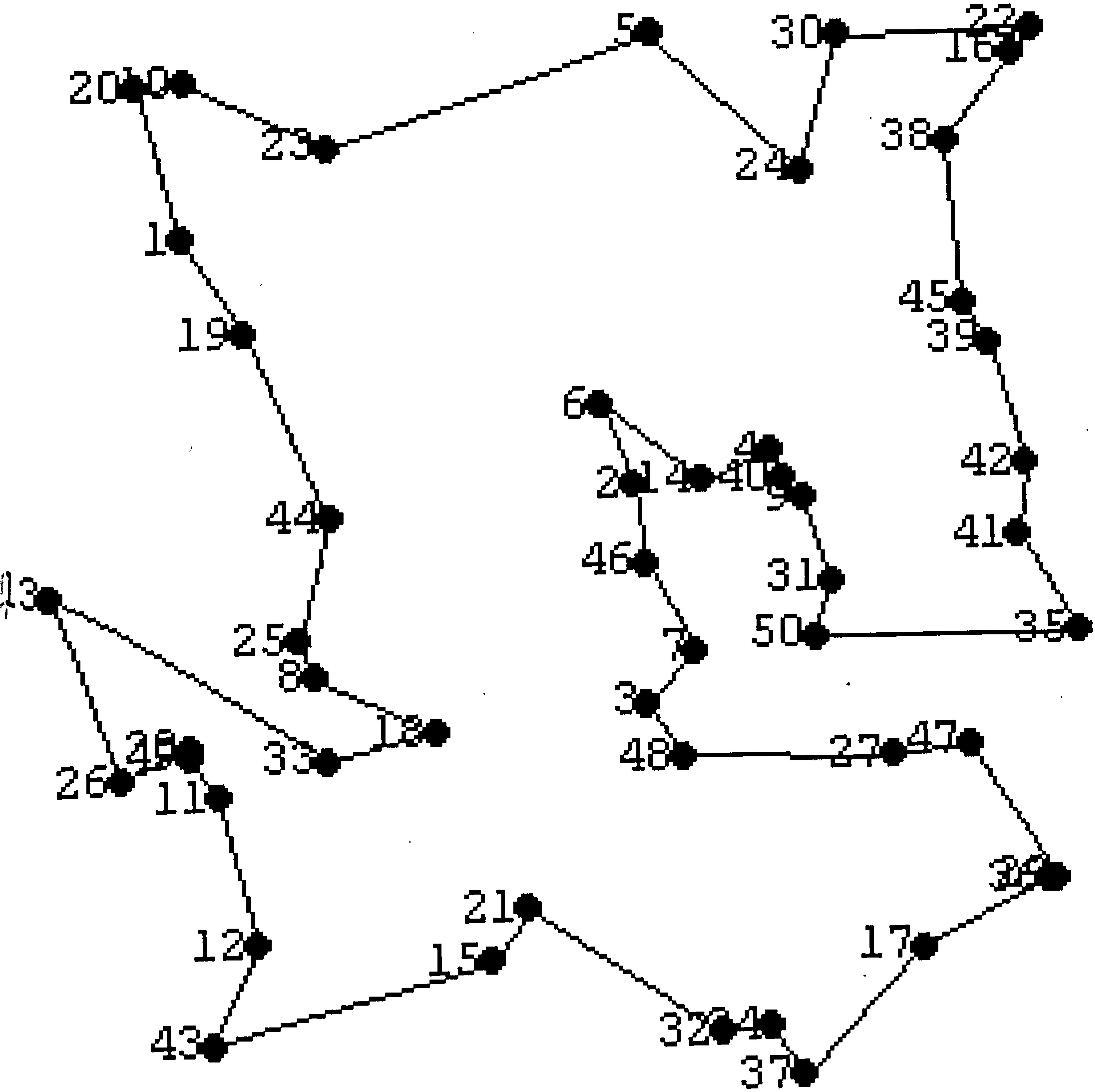
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Figure 7

Application of the T-Square Method

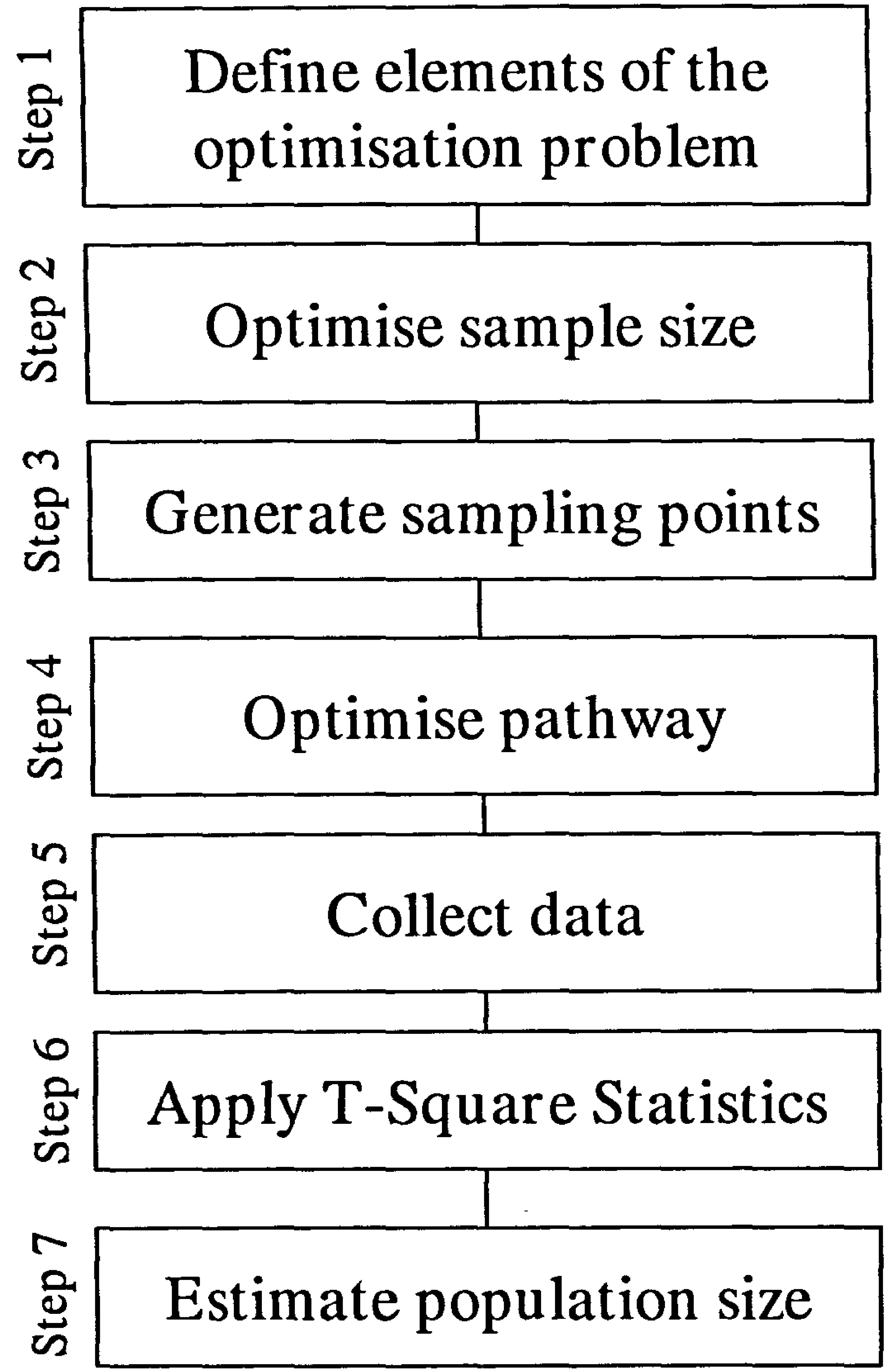

Figure 8


Cost of survey / cost of BSU
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
C_{ratio}=450
Δ ±10%
ρ=0.50
ρ=0.40
ρ=0.31
ρ=0.20
ρ=0.10
ρ=0.05
0
1
10
20
32
40
60
80
95
100
Average 'take'

Figure 9

Emerging Themes in Epidemiology

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Methods for health surveys in difficult settings: charting progress, moving forward

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Methods for health surveys in difficult settings: charting progress, moving forward

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Abstract

Health surveys are a very important component of the epidemiology toolbox, and play a critical role in gauging population health, especially in developing countries. Research on health survey methods, however, is sparse. In particular, current sampling methods are not well adapted for certain 'difficult' settings, such as emergencies, remote regions without easily available sampling frames, hidden and vulnerable population groups, urban slums and populations living under strong political pressure. This special issue of *Emerging Themes in Epidemiology* is entirely devoted to survey methods in such settings, and builds upon a successful conference in London highlighting problems with current approaches and possible ways forward. Greater investment in research on health survey methods is needed and will have beneficial effects for populations in need.

Editorial

Health surveys are the stethoscope, thermometer and pressure gauge of global health. Measurement of the health-based Millennium Development Goals depends on large-scale surveys such as the Demographic and Health Surveys, Multiple Indicator Cluster Surveys, and Living Standard Measurement Surveys [1]. For most international health interventions, including preventive disease control, curative care, health system strengthening, and emergency relief, population surveys are necessary to monitor implementation. Surveys can also provide direct measures of health outcomes and impact at the population level, and highlight important differentials in exposures and/or disease risk within particular groups, thus providing a trigger for action.

Despite the contribution that survey data can make to global health improvement, research to develop survey methods in difficult settings has largely stagnated over the past two decades. A mere handful of studies on this topic have been published. This may be because of a perception that surveys do not require the same sophistication and rigour as other types of studies, such as clinical trials. Yet surveys present a number of technical challenges, including the need to select representative samples, achieve adequate statistical precision and minimise bias in data collection. In resource-rich, industrialised settings, the surveyor's task is mostly straightforward: here, situations are often stable; communities are administratively organised; people are largely familiar with the use of surveys; transport and logistics are not problematic; capacity for data collection and analysis is high; legal and socio-economic conditions tend to protect participants against the untoward effects of research; and, crucially, comprehensive, stable population lists are more readily available, allowing researchers to select a representative random sample, the gold standard of survey sampling. Furthermore, the existence of sophisticated health information systems relying on prospective surveillance, and the high utilisation of health services, often remove much of the need for surveys, at least as a tool for monitoring service coverage and health outcomes.

There are, however, many settings throughout the world where these conditions are not met and where the problems of imprecision and bias are compounded by formidable logistical challenges, as well as serious political, security, cultural or ethical constraints. A list of such "difficult" settings might include: humanitarian crises resulting from conflict and natural disasters; poor and/or remote developing country settings where survey design options are constrained by insufficient census or geographic data; "hidden" and/or vulnerable populations (such as sex workers, orphans, street children, victims of sexual and gender-based violence, undocumented migrants, nomadic communities, and women as a whole in some cultures); urban and peri-urban slums and other marginalised areas in developing country cities; and populations under strong political pressure, among whom data collection may be actively discouraged by authorities and/or entail considerable risks for beneficiaries and researchers. Paradoxically, it is precisely in these settings that surveillance data are most lacking, and surveys most badly needed to generate information about population health.

On 15 February 2006, the London School of Hygiene and Tropical Medicine (LSHTM) hosted its first international conference on health survey methodology in difficult settings [2]. The conference was attended by 125 participants from 31 institutions, including academic centres from Europe, United States of America and Australia, international non-governmental organisations (NGOs), United Nations agencies, and major public health institutions.

This special issue of *Emerging Themes in Epidemiology* is an outcome of the conference and has been developed with support from LSHTM and the Centre for Research on the Epidemiology of Disasters (CRED), Université Catholique de Louvain, Belgium. It represents a move to rekindle international interest in methodological aspects of health surveys. The issue showcases recent survey-related work in a variety of health-related fields, and encourages inter-disciplinary sharing of experience in an Open Access internet publication format.

Several contributions to this issue come from the humanitarian relief community. Over the past 30 years, surveys have been increasingly used for assessing, monitoring and guiding emergency operations in settings affected by conflict and natural disasters. In these settings, uncertain and rapidly-changing sampling frames are common, working conditions are challenging, data collection is not considered a priority, and political sensitivities abound. In his opinion piece, Spiegel [3] considers the role of various humanitarian stakeholders (NGOs, United Nations agencies, and academic centres) in the implementation of surveys in such conditions, and offers recommendations for how to improve existing practices through standardisation of methodologies, better training for field staff, timely deployment of skilled epidemiologists, and inter-agency peer review. Degomme and Guha-Sapir [4], from CRED, reflect on the creation of a database of surveys conducted in emergencies, and explore it to describe and interpret recent global trends.

Prudhon and Spiegel [5] review the validity of more than 350 mortality, nutrition and vaccination coverage surveys conducted during the last decade. This review both updates and improves upon previous work on nutritional [6] and HIV serological and behavioural surveys (Paul Spiegel, unpublished data), offering a much-needed reality check on the quality of survey work. No health topic is as fundamental as mortality and, in crises, its measurement is of crucial importance for both operational planning and advocacy. Moreover, as shown by recent work in Darfur [7] and Iraq [8], such surveys can be politically as well as methodologically controversial. Although manuals and guidance exist, survey methods used to estimate mortality retrospectively are only partially validated, and a number of methodological questions remain outstanding. The Working Group for Mortality Estimation in Emergencies [9] highlights several of these and suggests a set of best practice procedures.

These first four papers could not be more timely given the current drive to establish a global system to track the evolution of major crises through the systematic implementation of mortality and nutrition surveys [10]. The bottom line is that, while the quality of humanitarian surveys is improving, progress is slow and demand for data considerably outstrips present capacity. As a start, where guidelines exist, they should be adhered to more rigorously and adequate resources must be set aside to allow for sound data collection.

There are nonetheless many situations for which existing data collection methods do not offer feasible solutions and these often concern the most vulnerable and deprived populations. Approaches to deal with the lack of adequate sampling frames are painfully limited and have advanced little in the past decades. Traditionally, the main solution has been cluster sampling, whereby a representative number of starting points is selected within the target population based on probability proportional to size. Individuals or households around these points are then included using a variety of sampling methods. The standard 30x7 and 30x30 cluster designs, with household selection performed according to the Expanded Programme on Immunisation (EPI) method (perhaps more familiar to readers as "spin-the-pen" [11]), has been adopted widely, usually without sufficient appreciation of its limitations. This formulaic approach often leads to neglect of appropriate sample size calculation (i.e. considering the optimal number of clusters and households) and insufficient recognition of the need to plan for the effect of clustering (i.e. the design effect) and account for this in the analysis.

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